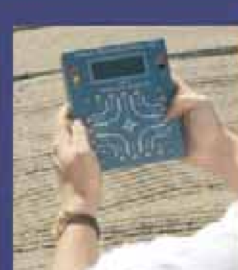
Traffic Studies and Evaluations for

LINCOLN'S ARTERIAL STREETS 2002-2003

CITY OF LINCOLN
NEBRASKA

Submitted to
City of Lincoln, Nebraska
Public Works and Utilities Department
February 2004

PROJECT REPORT



Traffic Systems Solutions Co.

THE SCHEMMER ASSOCIATES

Project Report for

TRAFFIC STUDIES & EVALUATIONS FOR LINCOLN'S ARTERIAL STREETS 2002-2003

Submitted to

CITY OF LINCOLN, NEBRASKA
PUBLIC WORKS & UTILITIES DEPARTMENT

Submitted by

THE SCHEMMER ASSOCIATES INC.
&
TRAFFIC SYSTEMS SOLUTIONS CO.

February 2004

EXECUTIVE SUMMARY

It is the goal of the City of Lincoln, Public Works and Utilities Department, Engineering Services Division, to monitor the City's main arterials over time. Approximately every three years, each arterial should be monitored to track traffic patterns, growth and operations. In Spring 2002, the City contracted The Schemmer Associates Inc. to conduct an analysis and study of traffic conditions on six corridors. Two additional corridors were added to the contract in Fall 2002. Along these eight corridors, travel time and intersection delay studies were conducted with the goal of improving traffic operations through modified signal timings, rather than by widening City streets or other physical roadway improvements.

This report summarizes three tasks conducted as part of this project. These tasks include:

1. Performing signal timing optimization and coordination analysis for eight study corridors, including:

   - 9th/10th Streets (Van Dorn Street to "Q" Street)
   - 16th/17th Streets (South Street to Vine Street (17th Street)/"W" Street (16th Street))
   - "O" Street (9th Street to 33rd Street)
   - Normal Boulevard/Capitol Parkway/"K" & "L" Streets (9th Street to 56th Street)
   - Superior Street (I-180 to Cornhusker Highway)
   - Cornhusker Highway (11th Street to Superior Street/Havelock Avenue)
   - S. 27th Street (Van Dorn Street to "O" Street)
   - N. 27th Street ("O" Street to Kensington Drive)

2. Conducting "before" and "after" travel time and intersection delay studies along the eight study corridors.

3. Conducting data collection activities, including 6-hour turning movement counts at 20 signalized intersections and 48-hour mechanical ("tube") counts at 50 locations.

Results from these studies were used to estimate the mobility benefits that are generated through the modification of traffic signal timings. As a result of the signal timing modifications made along these eight corridors, an estimated $722,000 in annual mobility benefits can be expected during the three peak time periods. Over a three-year period, these savings can be as high as $2,166,000.

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This report is a tool to be used internally by the City of Lincoln, Public Works and Utilities Department to continuously monitor traffic flow along arterial streets and make signal timing adjustments necessary to accommodate changes in traffic volumes and travel patterns. The objectives of the signal timing adjustments are to maximize the progression of vehicles along the arterial (reduce travel time) and optimize individual intersection operations (minimize delay). However, achieving both objectives simultaneously may not always be possible.

INTRODUCTION

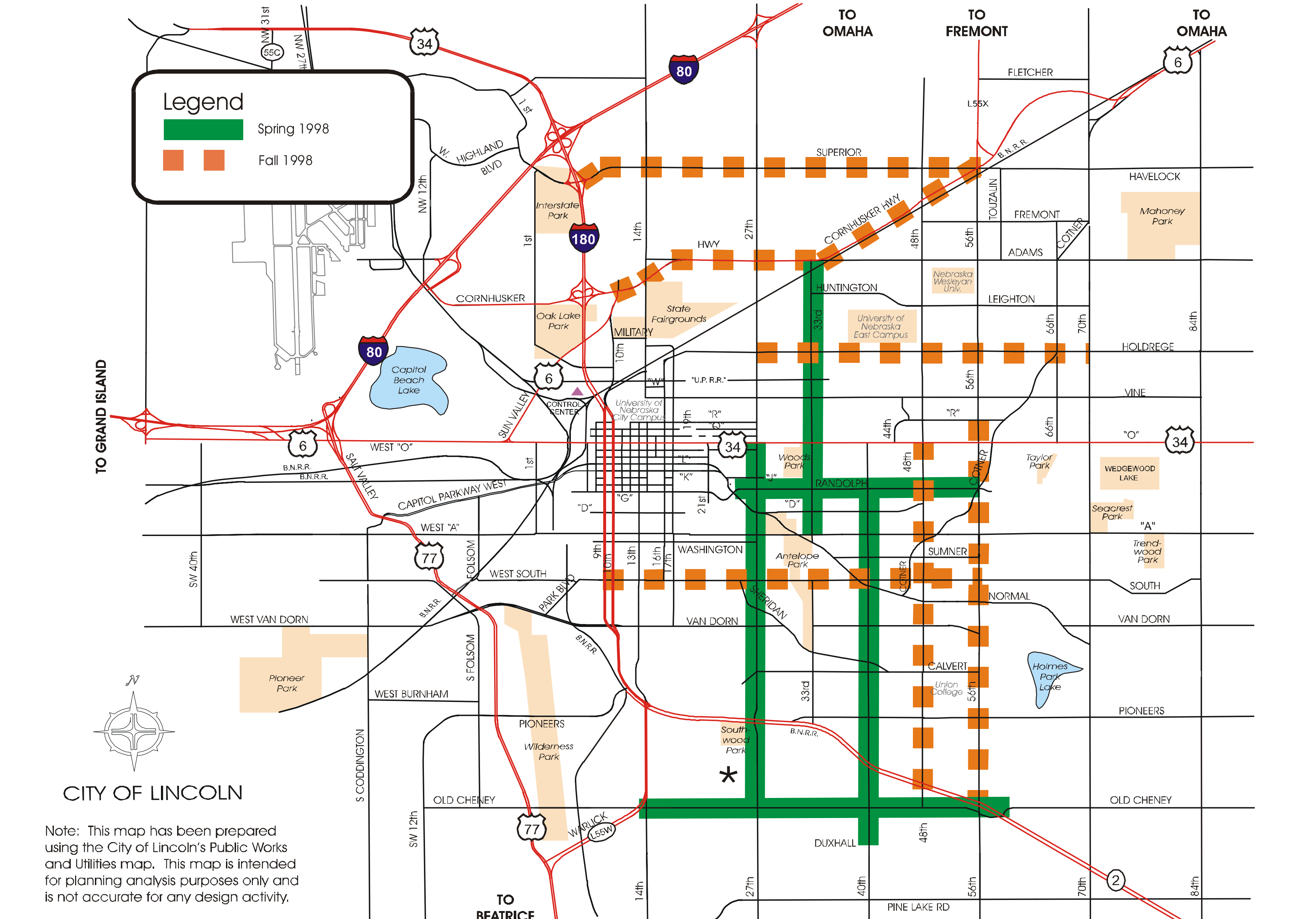
It is the goal of the City of Lincoln, Public Works and Utilities Department, Engineering Services Division, to monitor the City's main arterials over time. Approximately every three years, each arterial should be monitored to track traffic patterns, growth and operations. In Spring 1998, the City contracted The Schemmer Associates Inc. (TSA) to conduct an analysis and study of traffic conditions on ten arterial corridors to use as a framework for future arterial evaluations. Along these ten corridors, travel time and intersection delay studies were conducted with the goal of improving traffic operations (decreasing delay and travel time) through modified signal timings, rather than by widening City streets or other physical roadway improvements. The ten corridors included in this contract included:

- South 27th Street (Old Cheney Road to "O" Street)
- North/South 33rd Street ("A" Street to Cornhusker Highway)
- South 40th Street (Duxhall Drive to Randolph Street)
- South 48th Street (Nebraska Highway 2 to "O" Street)
- Superior Street (I-180 to Cornhusker Highway)
- Cornhusker Highway (11th Street to Superior Street/Havelock Avenue)
- Holdrege Street (27th Street to 70th Street)
- Randolph Street (Capitol Parkway to 56th Street/Cotner Boulevard)
- South Street (9th Street to 56th Street)
- Old Cheney Road (Warlick Boulevard to Nebraska Highway 2)

As a result of studies being performed as part of the East "O" Street Project (1999), an 11th corridor was added to this list:

- 56th Street (Nebraska Highway 2 to "R" Street)

All of the corridors listed above, which were studied during the Spring of 1998 and Fall of 1998, are shown in Figure 1.



Note: This map has been prepared using the City of Lincoln's Public Works and Utilities map. This map is intended for planning analysis purposes only and is not accurate for any design activity.

* Due to construction schedules south of Old Cheney Road, travel-time studies along 27th Street terminated at Tierra Drive, however, signal timing analysis was performed south through Old Cheney Road.

Figure 1: 1998 Travel Time Study Corridors

In April 2000, TSA was contracted to conduct studies along six additional corridors as listed below:

- North 27th Street ("O" Street to I-80)
- North 48th Street ("O" Street to Superior Street)
- North 70th Street ("O" Street to Havelock Avenue)
- Nebraska Highway 2 (Old Cheney Road to Van Dorn Street)
- Pioneers Boulevard (33rd Street to 56th Street)
- Vine Street (14th Street to 70th Street)

These corridors are shown in Figure 2.

Recently, in February 2002, TSA was contracted to study six additional corridors as listed below:

- 9th/10th Streets (Van Dorn Street to "Q" Street)
- 16th/17th Streets (South Street to Vine Street (17th Street)/"W" Street (16th Street))
- "O" Street (9th Street to 33rd Street)
- Normal Boulevard/Capitol Parkway/ "K" & "L" Streets (9th Street to 56th Street)
- Superior Street (I-180 to Cornhusker Highway)
- Cornhusker Highway (11th Street to Superior Street/Havelock Avenue)

Based on proximity and relationship to the above six corridors, two corridors were added to this list:

- South 27th Street (Van Dorn Street to 'O' Street)
- North 27th Street ('O' Street to Kensington Drive)

These corridors, which were studied in the Spring and Fall of 2002 and the Spring of 2003, are shown in Figure 3.

Tasks performed as part of this project include:

1. Performing signal timing optimization and coordination analysis for these eight corridors. The objective of this task was to provide a coordinated traffic signal system to reduce vehicle delays not only along the specified corridors, but also at the intersecting cross-street approaches.

2. Conducting "before" travel time studies along seven arterial corridors and "after" travel time studies along eight arterial corridors. "Before" intersection delay studies were conducted at 44 locations, and "after" intersection delay studies were conducted at 46 locations. The objective of this task was to perform traffic engineering studies to quantify changes in traffic operations resulting from signal timing modifications. As described previously in this section, this task is also used to monitor the City's main arterials to track traffic patterns, growth and operations over time. Since the

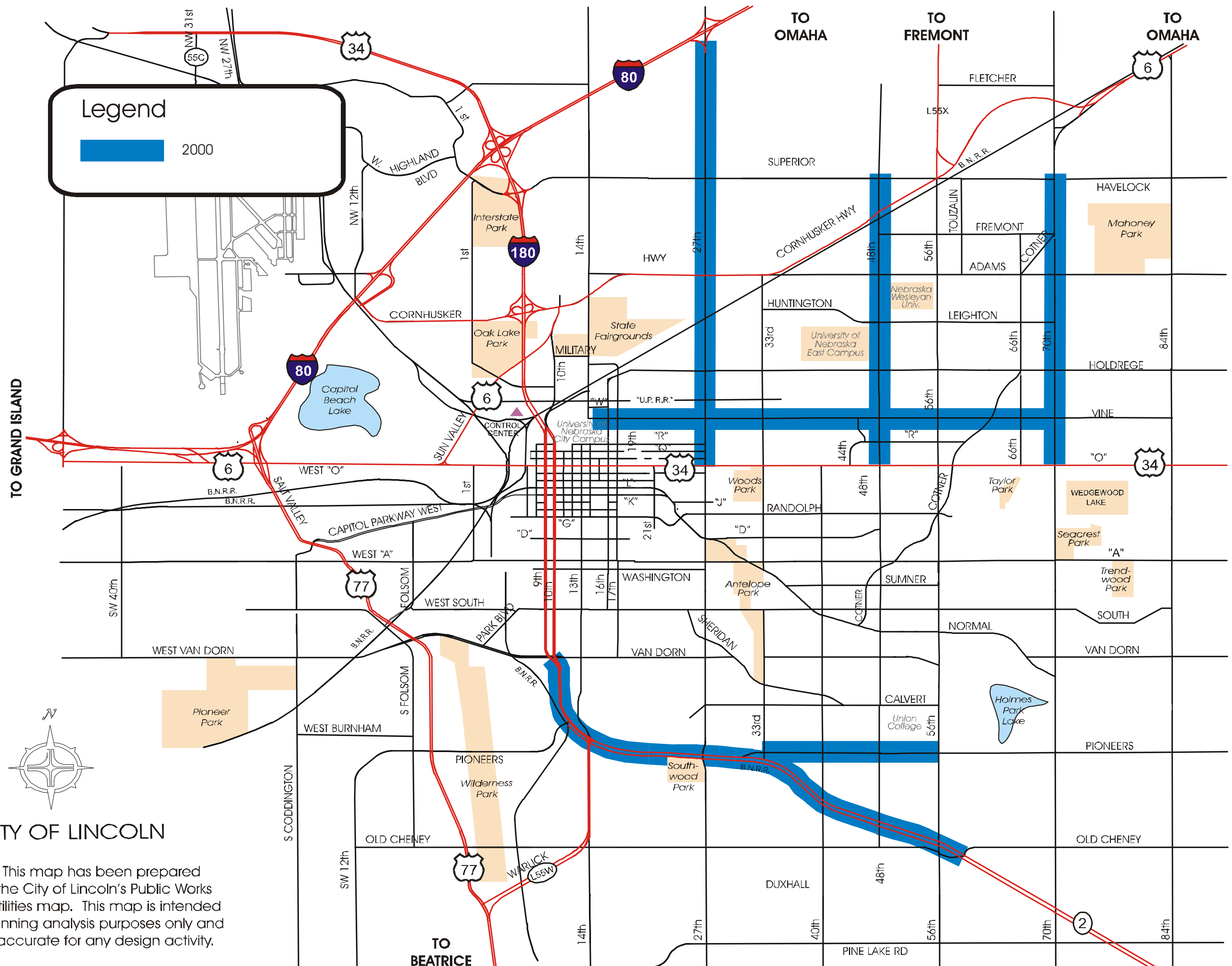


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Figure 2:
2000 Travel Time Study Corridors

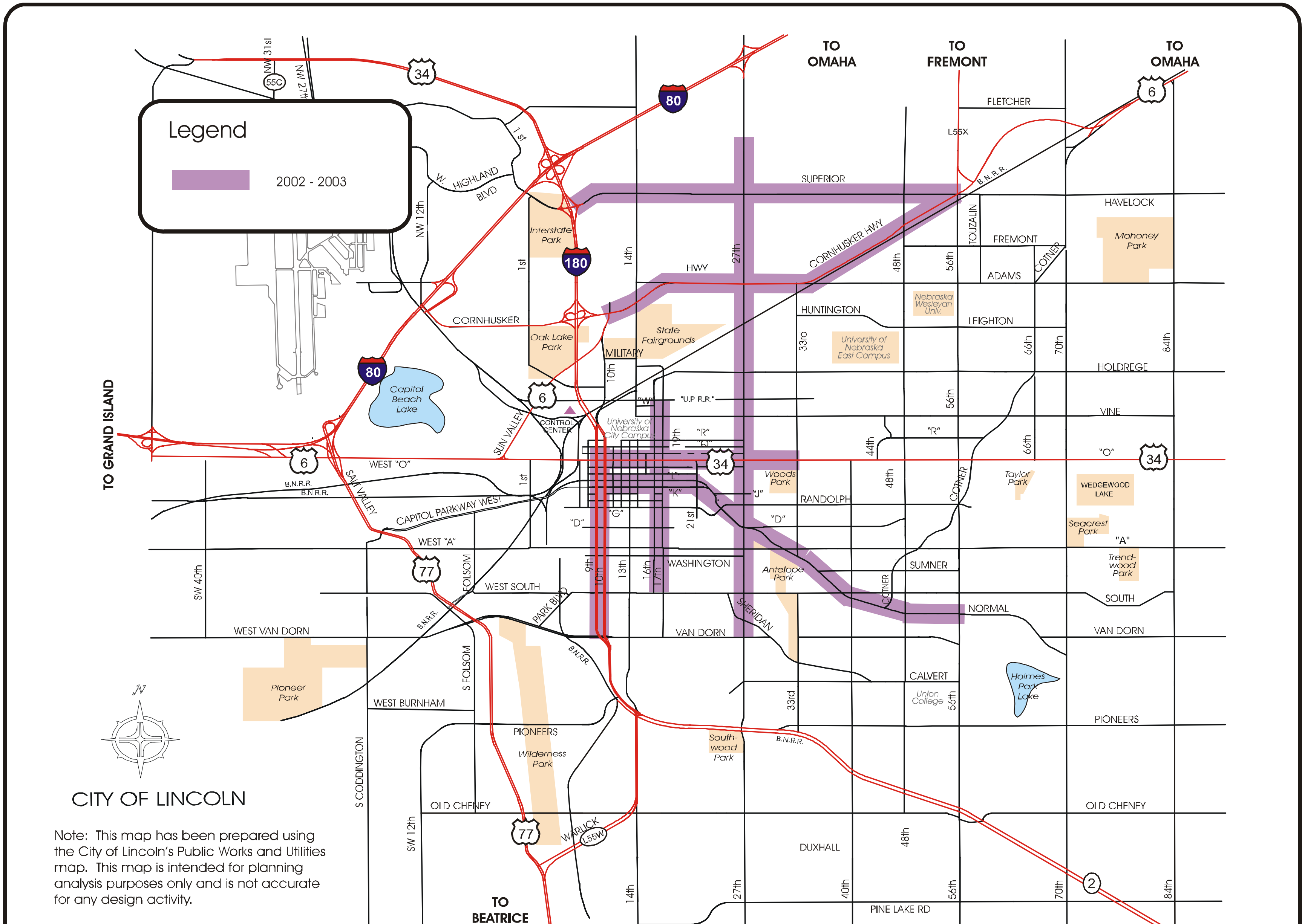

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Figure 3:
2002-2003 Travel Time Study Corridors

North 27th Street corridor was previously studied in Fall 2000, results of the "after" studies from the 2000 contract were used as the "before" study results for comparison to the "after" studies for this contract.

3. Conducting traffic volume data collection activities, including 6-hour turning movement counts at 20 signalized intersections and 48-hour mechanical ("tube") counts at 50 locations. The turning movement counts were collected at intersections within the eight study corridors that required updated turning movement volumes. The mechanical counts were collected at locations throughout the City for general use by City staff and others.

All data collection activities, methodologies and calculations related to the travel time and intersection delay studies were performed based on nationally accepted engineering practices outlined by the Institute of Transportation Engineers (ITE).

SIGNAL TIMING DEVELOPMENT

The goal of this task was to develop optimum signal timings and progression alternates for each of the eight study corridors. This included the evaluation of the existing signal timing plans in order to make recommendations for improvements to the cycle lengths, phase sequences and phase splits to improve mobility through the corridors.

Focus Area Analysis

In order to provide efficient signal timing coordination, it is important, at times, to include intersections that are not part of the corridor but are adjacent to the study corridor(s). A focus area analysis was conducted prior to the initiation of the signal-timing task. The purpose of the focus area analysis was to identify intersections that are not along the study corridors but are in close enough proximity that they impact, or are impacted by, traffic and signal operations along a corridor. The criteria developed for the focus area analysis, described in the "Focus Area Analysis Technical Memorandum", June 2002, provided in Appendix A, included:

- Directional traffic volumes by time period
- Heavy turning movement volumes at controlling intersections
- Repetitive traffic patterns and associated congestion
- Continuity (i.e., interactive relationship to other corridors)
- Critical intersection(s) or flow links
- Regional importance
- Priority, relationship and proximity of the study corridors
- Physical/natural boundaries
- Signal timing characteristics, including pedestrian crossings
- Traffic signal grouping characteristics and local flow links

Utilizing the above criteria, it was determined that the intersection of 13th Street/South Street should be included in the analysis of 9th/10th Streets and 16th/17th Streets. Also, the intersection of 17th Street/Van Dorn Street should also be included in the analysis of 16th/17th Streets. Since four of the study corridors traverse through the downtown area, it was concluded that all other intersections within the downtown area would be included in the signal timing analysis and signal timing adjustments would be made to these intersections, as necessary, in order to maintain vehicle progression in the downtown area along non-study corridors, such as 14th Street and "P" Street, as much as possible.

Along Normal Boulevard, the intersection of 40th Street/South Street was included in the analysis due to its proximity with 40th Street/Normal Boulevard and South Street/Normal Boulevard. Also, the intersection 11th Street/Saunders Avenue was included in the analysis of Cornhusker Highway.

Existing Conditions

AM Peak, Midday and PM Peak hour turning movement counts, lane configurations, posted speed limits and signal timing information were collected as part of the data collection effort for existing conditions. This information was used to update the City's existing traffic model (Synchro).

Signal Timing Analysis

Signal timing analyses were performed with the assistance of two nationally accepted computer software packages, TSPP-Draft and Synchro, in developing optimized signal timing splits, cycle lengths, offsets and lead/lag phasing sequences.

The first step was the analysis of each sub-system for each corridor based on optimization of individual intersections without regard to system cycle length constraints. This analysis was based on the individual traffic demand at each intersection and the most efficient split to accommodate the individual demand.

The second step was to analyze each intersection as an element of the corridor with cycle length constraints. This analysis incorporated factors such as distance between intersections, cross-street traffic volumes and relationship to other coordinated corridors within the City of Lincoln signal system. In this analysis, priority was first given to signal timing progression on primary corridors. After primary corridors were optimized, other less critical or less demanding corridors were optimized for vehicle progression where it was possible and logical.

Signal Timing Implementation

The recommended signal timing modifications were presented to City of Lincoln staff for preliminary approval. Once approved, the timing information was programmed into the City's central computer system (ACTRA) and any timing discrepancies were identified and resolved. After programming and implementing the modified timings, field reviews were conducted to review the operation of the timings and make any necessary adjustments in cycle lengths, splits and offsets based on observed traffic flow characteristics. A summary of the signal timing changes made to the eight corridors and the downtown area is included in Appendix B. These summaries include signal timing cycle length, split, offset and phase sequence changes for each intersection.

SUMMARY OF "BEFORE" AND "AFTER" STUDIES

The recommended signal timing modifications were evaluated by conducting travel time studies along each of the eight corridors *before* signal timing improvements were made, and again *after* implementation of the new signal timings. Also, "before" and "after" intersection delay studies were conducted at 46 signalized intersections to measure the amount of stopped-delay experienced by vehicles at these individual intersections.

The stated goal of the City is to have its streets operate at or above LOS 'C', which describes stable operations. However, ability to maneuver and change lanes at mid-block locations may be more restricted. Figure 4 illustrates the basic measure of arterial LOS and congestion as it relates to average speed, for arterials with typical free flow speeds of 35 mph. Table 1 summarizes the range in average speed and corresponding LOS for each of the four urban street classes according to Exhibit 15-2 of the *2000 Highway Capacity Manual* (HCM).

Table 1: Urban Street LOS by Class

Urban Street Class	I	II	III	IV
Range of free-flow speeds (FFS)	55 to 45 mph	45 to 35 mph	35 to 30 mph	35 to 25 mph
Typical FFS	50 mph	40 mph	35 mph	30 mph
LOS	Average Travel Speed (mph)			
A	> 42	> 35	> 30	> 25
B	> 34-42	> 28-35	> 24-30	> 19-25
C	> 27-34	> 22-28	> 18-24	> 13-19
D	> 21-27	> 17-22	> 14-18	> 9-13
E	> 16-24	> 13-17	> 10-14	> 7-9
F	≤ 16	≤ 13	≤ 10	≤ 7

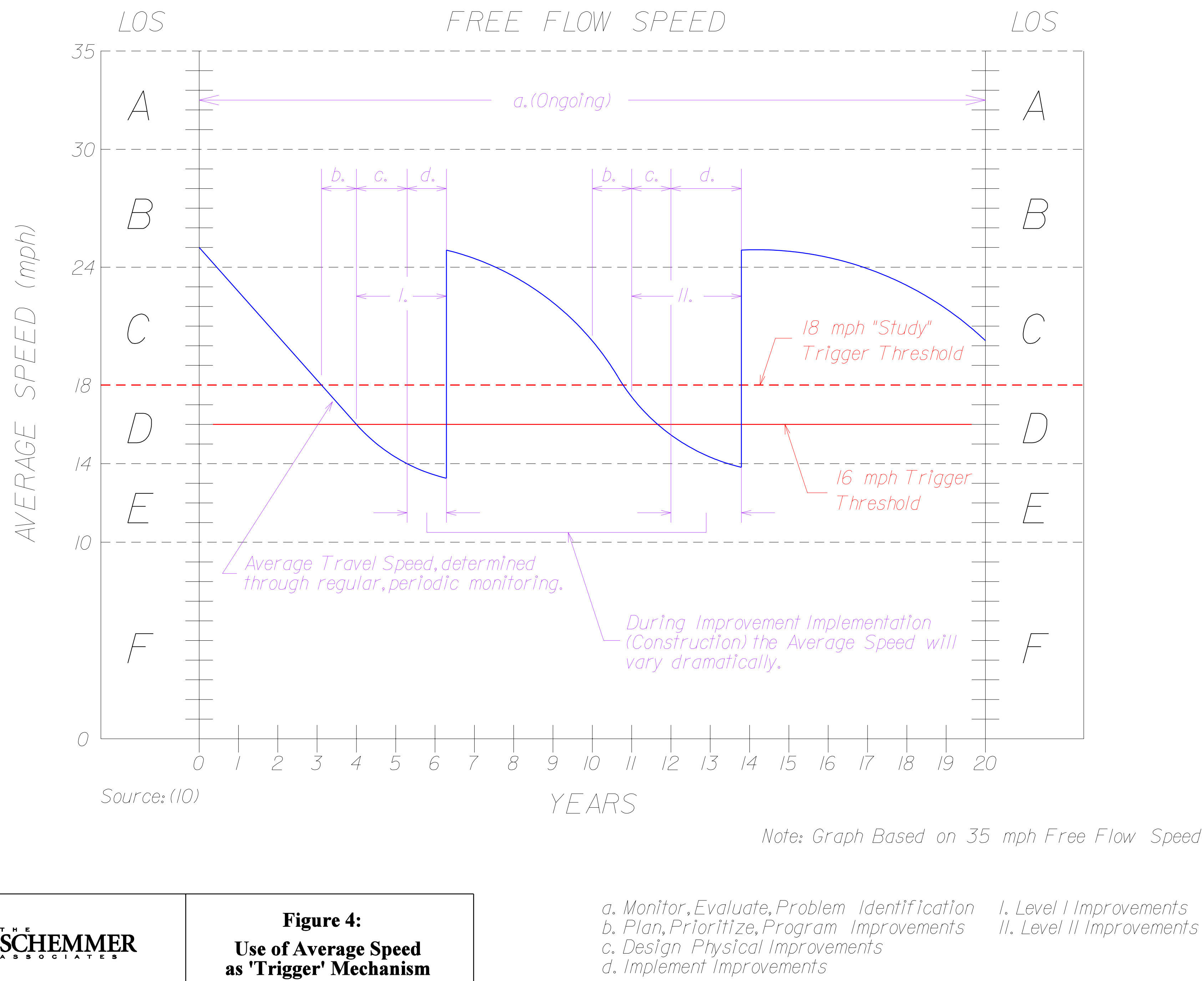

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Figure 4:
Use of Average Speed as 'Trigger' Mechanism

Travel Time Studies

Travel time is the elapsed time for a vehicle to traverse a given segment of a street. Travel time studies provide the necessary data to determine the average travel time. Combined with the length of the corridor under study, this data can be used to produce average travel speed. Travel time and delay are two of the principal measures of roadway system performance used by traffic engineers, planners and analysts. Since vehicle speed is directly related to travel time and delay, it is also an appropriate measure-of-effectiveness (MOE) to evaluate traffic systems.

Travel time studies were conducted noting the sources and amount of delay occurring within the study corridor. Each of the study corridors were divided into several "links", which were defined by signalized intersections or signalized pedestrian crosswalks. The boundaries of these links were identified as the far-side curb of the intersection, or just beyond each of the signalized locations. Therefore, delay for a particular intersection was included in the total delay of the link ending at that intersection.

The ITE *Manual of Traffic Engineering Studies* recommends that the comparison of "before" and "after" studies have a range of permitted error of ±1 to ±3 mph. ITE also recommends using the average range in running speed (i.e., the distance traveled divided by the running time[1]) to determine the minimum number of individual runs necessary to achieve an acceptable range of error. This accepted methodology predicts that with eight (8) separate runs, and a maximum average range in running speed of 5.0 mph, a confidence level of 95% is achieved, with a permitted error of ±1 mph. Therefore, a minimum of eight runs were conducted for each corridor, during each time period and in each direction for both the "before" and "after" conditions.

Travel time studies were conducted for each of the study corridors during the AM Peak (7:00-8:30 a.m.), Midday (11:00 a.m.-1:00 a.m.) and PM Peak (4:00-6:00 p.m.) time periods. In addition, all travel time studies were conducted on days that are representative of Lincoln's average traffic day. These are days with dry and clear weather conditions, all schools and universities are in session and no special events (e.g., State Fair, state high school athletic tournaments, Fridays before home Nebraska football games) are taking place.

Travel time data was collected using equipment manufactured by Jamar Technologies, Inc. Using sensors attached to the vehicle's transmission, electronic pulses are converted to units of distance and sent to a hand-held electronic data collection device (TDC-8) that records the information in one-second intervals. A software package, PC-TRAVEL, was then used to analyze the data, including calculating total travel time, average speed and total delay. Additional statistical computations were performed by TSA to determine standard deviations and confidence intervals.

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[1] *Running time* is the time a vehicle is actually in motion (or moving faster than a pre-designated speed) while traversing a given segment of street or highway.

Definitions of Travel Time Statistics

The following is a list of the variables, and their respective definitions, reported in the travel time study summaries:

Section Number – each travel-time corridor is divided into individual links, or sections, usually defined by a signalized intersection or pedestrian crosswalk. The *section number* is the sequential numbering of these sections.

Length – the average length, in feet, of the individual sections and the overall corridor.

Section Name – the name of the street or pedestrian crossing that defines the downstream end of the individual sections.

Average Travel Time – the average time, in seconds, elapsed while driving between two points along a corridor.

Standard Deviation – (sec, mph) a measure of the variability of the travel time and average speed.

Average Stops – the average number of stops experienced by section and overall corridor. A stop is defined as a one-second interval where the speed is less than 5 feet per second and the speed was greater than 5 feet per second during the previous one-second interval. Therefore, each time the vehicle slows down and crosses the 5 feet per second threshold, a stop is counted. The vehicle must exceed the threshold before another stop can be counted. When a car stops in queue, slight creeping will not be counted as multiple stops.

Average Speed – (mph) computed by dividing the length of a section or corridor by the average travel time of that same section or corridor.

95% Confidence Interval – (mph) a measure of how well the average speed, calculated from the actual travel time runs, represents the actual average of the entire population. In other words, one can say, with 95% certainty, that the average speed of the entire driving population falls within the range defined by the sample average speed, plus/minus the 95% Confidence Interval. (See also definition for "Average Speed Within This Range".)

Average Speed Within This Range – (mph) the upper and lower limits for the variation in average speed.

Defined As: Lower Limit = (Average Speed – Confidence Interval)
Upper Limit = (Average Speed + Confidence Interval)

Time Duration Below - (sec) the three columns under this variable summarize the amount of time, in seconds, when the vehicle speed was less than or equal to 0, 7 and 28 mph, respectively. These three speeds are commonly used to represent the speed below which a car is stopped, queued and delayed on a typical urban street. Speeds above 28 mph are considered "free running".

Average Delay – difference between the actual travel time and the ideal travel time.

Ideal Travel Time (Unrestricted Travel Time) – the time it would take to traverse the section/corridor at the posted speed limit.

Number of Runs – the number of times the corridor was driven in a specific direction during the noted time period.

Posted Speed Limit – the speed limit posted along the roadway. The posted speed limit is used to calculate the ideal travel time for the corridor. Since the posted speed limit can vary within a particular study corridor, the ideal travel time is computed for each individual segment of the corridor using the posted speed limit for that segment.

The following eight sections summarize the results of the "before" and "after" travel time studies. Detailed "before" and "after" travel time summaries for each corridor, time period and direction are provided in Appendix C. These summaries also provide average travel time statistics for the individual segments that comprise each of the eight corridors.

9th/10th Streets (Van Dorn Street to "Q" Street)

Tables 2a and 2b summarize the results of the travel time studies conducted along 9th and 10th Streets. The limits of this corridor were defined by the intersections at Van Dorn Street on the south and "Q" Street on the north. Between Van Dorn Street and "G" Street, both 9th and 10th Streets are characterized by mostly residential land uses, with a couple of small commercial land uses interspersed. From "G" Street to "Q" Street, 9th and 10th Streets run north and south through the western portion of downtown Lincoln. 9th Street has a posted speed limit of 25 mph between "Q" Street and "M" Street and 35 mph from "M" Street to Van Dorn Street. 10th Street has a posted speed limit of 35 mph between Van Dorn Street and "M" Street and 25 mph from "M" Street to "Q" Street.

From the results of the "after" studies, average travel time and delay along both 9th and 10th Streets was improved, with the exception of 9th Street during the AM Peak. The most significant improvements were observed during the PM Peak, with average delay decreasing by 34.9 sec/veh along 10th Street and by 39.1 sec/veh along 9th Street.

Detailed analysis of both 9th and 10th Streets also indicated that only a few, specific segments along 10th Street contributed significantly to the overall corridor delay. These segments are summarized in Table 3. The remaining delay experienced along both 9th and 10th Streets during the three peak time periods was more evenly dispersed among the various segments of the corridor.

Table 2a: "Before" Travel Time Studies-9th & 10th Streets (Van Dorn to "Q" Streets)

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2:	Thurs., 4/4/02 Tues., 4/16/02		Wed., 4/3/02 Tues., 4/16/02		Wed., 4/3/02 Tues., 4/16/02	
Travel Time Statistic	10th Street - NB	9th Street - SB	10th Street - NB	9th Street - SB	10th Street - NB	9th Street - SB
Average Travel Time (sec/veh)	311.5	278.4	294.3	263.0	306.8	309.0
Standard Deviation (sec/veh)	45.2	24.7	31.3	24.4	31.9	51.8
Average Number of Stops/veh	2.2	1.0	1.4	0.5	1.6	2.2
Average Delay (sec/veh)	**81.1**	**44.8**	**62.8**	**29.7**	**74.6**	**75.9**
Number of Runs	11	10	15	16	14	15
Length (feet)	11,301	11,349	11,292	11,333	11,295	11,324
Average Speed (mph)	24.7	27.8	26.2	29.4	25.1	25.0
Standard Deviation (mph)	3.3	2.6	2.5	2.8	2.9	3.9
95% Confidence Interval (mph)	2.0	1.6	1.3	1.4	1.5	2.0
Average Speed Within This Range (mph)[1] Lower Limit: Upper Limit	22.7 26.7	26.2 29.4	24.9 27.5	28.0 30.8	23.6 26.6	23.0 27.0
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	28.9 40.5 168.9	16.0 22.8 112.3	26.1 34.1 133.7	9.8 12.3 82.7	34.0 42.4 149.5	29.2 43.4 136.1

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: 9th Street-"Q" Street to "M" Street = 25 mph
9th Street-"M" Street to Van Dorn Street = 35 mph
10th Street-Van Dorn Street to "M" Street = 35 mph
10th Street-"M" Street to "Q" Street = 25 mph

Ideal Travel Time = 233.3 seconds (3 minutes, 53.3 seconds)

Table 2b: "After" Travel Time Studies-9th & 10th Streets (Van Dorn to "Q" Streets)

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2:	Mon., 3/10/03 Wed., 3/12/03		Mon., 3/10/03 Tues., 4/1/03		Mon., 3/10/03 Tues., 4/1/03	
Travel Time Statistic	10th Street - NB	9th Street - SB	10th Street - NB	9th Street - SB	10th Street - NB	9th Street - SB
Average Travel Time (sec/veh)	310.3	283.0	284.0	253.1	272.1	270.1
Standard Deviation (sec/veh)	44.1	53.9	30.1	20.5	45.6	36.3
Average Number of Stops/veh	1.2	0.8	1.1	0.5	0.8	0.5
Average Delay (sec/veh)	**77.3**	**50.0**	**52.8**	**21.2**	**39.7**	**36.8**
Number of Runs	10	11	15	15	15	15
Length (feet)	11,327	11,378	11,284	11,347	11,299	11,329
Average Speed (mph)	24.9	27.4	27.1	30.6	28.3	28.6
Standard Deviation (mph)	3.6	4.4	2.8	2.2	4.4	3.3
95% Confidence Interval (mph)	2.2	2.6	1.4	1.1	2.2	1.7
Average Speed Within This Range (mph)[1] Lower Limit: Upper Limit	22.7 27.1	24.8 30.0	25.7 28.5	29.5 31.7	26.1 30.5	26.9 30.3
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	27.6 35.5 164.9	22.3 27.5 100.4	24.3 29.9 113.1	6.9 9.2 65.5	14.6 21.0 96.9	9.7 12.1 94.0

Table 3: Segments Contributing Considerably to Overall Delay – 9th & 10th Streets

Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Delay
AM Peak	10th Street – NB	"K" Street – "L" Street	26.6	34%
Midday	10th Street – NB	"L" Street – "M" Street	17.0	32%
PM Peak	10th Street – NB	"O" Street – "P" Street	12.1	29%

During the AM Peak, 10th Street from "K" Street to "L" Street had an average delay of 26.6 sec/veh, which accounts for more than one-third of the overall delay along 10th Street. This amount of delay, however, can be reasonably expected and is most likely due to the high northbound volumes and large platoons traversing through this segment and the transition from a 35 mph posted speed limit to a 25 mph posted limit as vehicles enter the downtown area. Relatively significant amounts of delay were also experienced between "L" Street and "M" Street during the Midday and between "O" Street and "P" Street during the PM Peak, which were unexpected and do not appear to be representative of the implemented signal timing plans. Delays were not experienced within these two segments during field reviews and observations of the timing plans, and therefore, reasons for delay of this magnitude are not apparent.

16th/17th Streets (South Street to Vine Street (17th Street)/"W" Street (16th Street))

Tables 4a and 4b summarize the results of the travel time studies conducted along 16th and 17th Streets. The limits of this corridor were defined by South Street on the south and "W" Street on the north for 16th Street and Vine Street for 17th Street. 16th and 17th Streets are generally characterized by residential areas from South Street to "G" Street, with a medium-sized commercial area along South Street. The remainder of the corridor runs through the downtown area and a portion of the University of Nebraska-Lincoln campus. The corridor has posted speed limits of 35 mph between South Street and "M" Street and 25 mph from "M" Street to "W" Street and Vine Street.

Table 4a: "Before" Travel Time Studies-16th & 17th Streets (South to Vine (17th St.)/"W"(16th St.))

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: / Day 2:	Fri., 4/5/02 / Thurs., 4/11/02		Thurs., 4/4/02 / Thurs., 4/11/02		Thurs., 4/4/02 / Thurs., 4/11/02	
Travel Time Statistic	17th Street - NB	16th Street - SB	17th Street - NB	16th Street - SB	17th Street - NB	16th Street - SB
Average Travel Time (sec/veh)	264.5	315.8	255.7	330.8	340.0	483.3
Standard Deviation (sec/veh)	44.6	29.9	29.7	25.7	46.1	114.7
Average Number of Stops/veh	0.9	1.8	0.5	2.7	3.6	5.4
Average Delay (sec/veh)	**34.4**	**70.0**	**25.5**	**83.2**	**108.4**	**235.8**
Number of Runs	12	13	16	16	12	12
Length (feet)	10,539	11,232	10,527	11,220	10,540	11,218
Average Speed (mph)	27.2	24.2	28.1	23.1	21.1	15.8
Standard Deviation (mph)	4.4	2.3	2.9	1.9	2.9	4.1
95% Confidence Interval (mph)	2.5	1.3	1.4	0.9	1.6	2.3
Average Speed Within This Range (mph)[1]						
Lower Limit:	24.7	22.9	26.7	22.2	19.5	13.5
Upper Limit	29.7	25.5	29.5	24.0	22.7	18.1
Time Duration Below: (sec/veh)						
0 mph	18.2	35.3	10.9	40.4	42.6	127.5
7 mph	22.5	46.5	13.5	56.3	65.2	182.7
28 mph	123.6	170.7	113.6	190.9	222.2	362.6

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit:
16th Street-"W" Street to "M" Street = 25 mph
16th Street-"M" Street to South Street = 35 mph
17th Street-South Street to "M" Street = 35 mph
17th Street-"M" Street to Vine Street = 25 mph

Ideal Travel Time -
16th Street = 247.9 seconds (4 min., 7.9 sec)
17th Street = 231.7 seconds (3 min, 51.7 sec)

Table 4b: "After" Travel Time Studies-16th & 17th Streets (South to Vine (17th St.)/"W"(16th St.))

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: / Day 2:	Mon., 3/31/03 / Tues., 4/1/03		Tues., 3/11/03 / Mon., 3/31/03		Tues., 3/11/03 / Mon., 3/31/03	
Travel Time Statistic	17th Street - NB	16th Street - SB	17th Street - NB	16th Street - SB	17th Street - NB	16th Street - SB
Average Travel Time (sec/veh)	261.6	338.0	251.5	338.9	317.7	357.4
Standard Deviation (sec/veh)	26.4	29.6	18.3	28.9	17.5	39.8
Average Number of Stops/veh	0.3	2.0	0.1	2.0	1.3	2.4
Average Delay (sec/veh)	**31.0**	**91.9**	**20.3**	**92.5**	**86.1**	**110.8**
Number of Runs	12	12	16	16	15	14
Length (feet)	10,531	11,207	10,524	11,204	10,523	11,200
Average Speed (mph)	27.4	22.6	28.5	22.5	22.6	21.4
Standard Deviation (mph)	2.4	1.9	1.8	1.9	1.1	2.4
95% Confidence Interval (mph)	1.4	1.1	0.9	0.9	0.6	1.3
Average Speed Within This Range (mph)[1]						
Lower Limit:	26.0	21.5	27.6	21.6	22.0	20.1
Upper Limit	28.8	23.7	29.4	23.4	23.2	22.7
Time Duration Below: (sec/veh)						
0 mph	7.8	35.4	3.0	35.4	41.3	47.7
7 mph	10.3	48.6	3.7	48.8	50.4	63.4
28 mph	116.5	197.8	105.3	207.0	189.7	225.0

Increases in average delay between the "before" and "after" studies occurred during the AM Peak and Midday time periods along 16th Street. Otherwise, average delay remained relatively unchanged or decreased on both 16th and 17th Streets during all other time periods. The most significant decrease in overall average delay was observed along 16th Street during the PM Peak. Results of both the "before" and "after" studies indicate that the overall average delay decreased by 125.0 sec/veh (53%) during the PM Peak along 16th Street.

Detailed analysis of both 16th and 17th Streets also indicated that only a few, specific segments along 16th and 17th Streets contributed significantly to the overall corridor delay. These segments are summarized in Table 3. The remaining delay experienced along both 16th and 17th Streets during the three peak time periods was more evenly dispersed among the various segments of the corridor.

Table 5: Segments Contributing Considerably to Overall Delay– 16th & 17th Streets

Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Delay
AM Peak	16th Street – SB	"W" Street – Vine Street "L" Street – "K" Street	22.2 28.4	24% 31%
Midday	16th Street – SB	"W" Street – Vine Street "L" Street – "K" Street	21.1 29.9	23% 32%
PM Peak	16th Street – SB	"M" Street – "L" Street "A" Street – South Street	28.8 25.9	26% 23%
	17th Street – NB	"J" Street – "K" Street	49.3	57%

The segment along 16th Street from "W" Street to Vine Street experienced a considerable amount of delay during both the AM Peak and Midday time periods. This is most likely due to the fact that the intersection of 16th Street/Vine Street services a significant volume of traffic that must compete for green time. This intersection is also characterized by a high volume of pedestrians crossing both Vine Street and 16th Street, which also has an influence on traffic flow through this intersection.

A higher proportion of the overall corridor delay was anticipated between "L" Street and "K" Street during the AM Peak and Midday and between "M" Street and "L" Street during the PM Peak along 16th Street by design of the timing plans. The higher delays are a direct result of planned interruptions in vehicle progression, stopping vehicles at the downstream intersection of the segment in order to maintain vehicle progression along major cross streets.

The segment of 16th Street between "A" Street and South Street also experienced a higher proportion of the overall corridor delay. This also is not unexpected since 16th Street does not continue as an arterial through South Street, requiring vehicles to turn either right or left and travel to a parallel arterial before continuing south. The required turning decreases vehicle speeds through the intersection, interrupting vehicle progression and increasing delay.

Between "J" Street and "K" Street along 17th Street, a considerable amount of delay was recorded. This is due to the high traffic volumes at the intersection of 17th Street/"K" Street, which must compete for green time. Since "K" Street carries significantly higher volumes than 17th Street at this intersection, more green time is given to "K" Street, creating longer delays along 17th Street between "J" Street and "K" Street.

"O" Street (9th Street to 33rd Street)

Tables 6a and 6b summarize the results of the travel time studies conducted along "O" Street. The limits of this corridor were defined by 9th Street on the west and 33rd Street on the east. The entire length of this corridor is characterized by commercial land uses, with the segment between 9th Street and 17th Street running through the downtown area. This corridor has posted speed limits of 25 mph between 9th Street and 17th Street, 35 mph between 17th Street and 27th Street, and 40 mph between 27th Street and 33rd Street.

"After" studies show a general decrease in overall corridor delay during all time periods, with the exception of the eastbound direction during the PM Peak, which increased by 45.7 sec/veh. The most considerable decrease in overall corridor delay occurred in the westbound direction during the AM Peak, decreasing by 49.9 sec/veh. Table 7 summarizes the segments of the corridor that contribute most considerably to the overall delay in each direction along the corridor.

Table 6a: "Before" Travel Time Studies-"O" Street (9th Street to 33rd Street)

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2:	Wed., 4/10/02 Mon., 4/15/02		Wed., 4/10/02 Mon., 4/15/02		Wed., 4/10/02 Mon., 4/15/02	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	347.8	352.0	378.5	337.5	398.3	429.2
Standard Deviation (sec/veh)	52.3	44.2	49.5	33.8	56.8	53.3
Average Number of Stops/veh	5.3	4.6	5.5	3.8	5.2	7.1
Average Delay (sec/veh)	**137.7**	**142.2**	**168.6**	**127.4**	**188.8**	**219.4**
Number of Runs	10	9	13	13	12	11
Length (feet)	9,816	9,803	9,805	9,812	9,792	9,798
Average Speed (mph)	19.2	19.0	17.7	19.8	16.8	15.6
Standard Deviation (mph)	3.3	2.5	2.3	1.9	2.3	2.1
95% Confidence Interval (mph)	2.0	1.6	1.3	1.0	1.3	1.2
Average Speed Within This Range (mph)[1]						
Lower Limit:	17.2	17.4	16.4	18.8	15.5	14.4
Upper Limit	21.2	20.6	19.0	20.8	18.1	16.8
Time Duration Below: (sec/veh)						
0 mph	69.3	72.2	83.4	62.8	102.4	113.7
7 mph	98.7	96.1	119.3	84.6	133.9	155.5
28 mph	235.8	257.0	278.1	232.2	297.7	336.7

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: 9th Street – 17th Street = 25 mph
17th Street – 27th Street = 35 mph
27th Street – 33rd Street = 40 mph

Ideal Travel Time = 210.1 seconds (3 min, 30.1 sec)

Table 6b: "After" Travel Time Studies-"O" Street (9th Street to 33rd Street)

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2:	Fri., 4/4/03 Tues., 4/8/03		Fri., 4/4/03 Tues., 4/8/03		Fri., 4/4/03 Tues., 4/8/03	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	324.3	300.5	328.7	330.1	441.3	389.4
Standard Deviation (sec/veh)	46.3	43.6	39.9	52.5	104.6	90.0
Average Number of Stops/veh	2.7	2.4	2.6	3.2	6.0	5.3
Average Delay (sec/veh)	**114.2**	**92.3**	**121.2**	**120.1**	**234.5**	**179.1**
Number of Runs	10	11	14	14	12	11
Length (feet)	9,820	9,822	9,822	9,807	9,807	9,823
Average Speed (mph)	20.6	22.3	20.4	20.3	15.2	17.2
Standard Deviation (mph)	2.9	3.1	2.4	3.4	4.7	4.0
95% Confidence Interval (mph)	1.8	1.8	1.3	1.8	2.7	2.4
Average Speed Within This Range (mph)[1]						
Lower Limit:	18.8	20.5	19.1	18.5	12.5	14.8
Upper Limit	22.4	24.1	21.7	22.1	17.9	19.6
Time Duration Below: (sec/veh)						
0 mph	59.9	39.7	49.2	43.7	129.5	91.9
7 mph	77.4	53.8	67.7	65.6	169.4	127.0
28 mph	205.2	184.4	222.9	231.2	352.3	291.9

Table 7: Segments Contributing Considerably to Overall Delay – "O" Street

Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Corridor Delay
AM Peak	Eastbound	9th Street – 10th Street 25th Street – 27th Street	20.0 26.4	18% 23%
Midday	Eastbound	21st Street – 25th Street 25th Street – 27th Street	20.9 17.6	17% 15%
	Westbound	33rd Street – 27th Street 19th Street – 17th Street	20.2 32.2	17% 27%
PM Peak	Eastbound	21st Street – 25th Street 25th Street – 27th Street	37.7 79.0	16% 34%
	Westbound	33rd Street – 27th Street 25th Street – 21st Street 19th Street – 17th Street 11th Street – 10th Street	46.2 28.5 31.1 29.3	26% 16% 17% 16%

Most of the segments that experience the most considerable portion of the overall corridor delay along "O" Street are those links that are defined by a major intersection at their downstream end. At these intersections, approaches along "O" Street and the cross-street approaches are characterized by high traffic volumes, thus competing for a limited amount of green time.

The segment between 21st Street and 25th Street also experienced considerable delay during the PM Peak. This is primarily due to the difference in cycle lengths, which results in a lack of coordination between signals at 21st Street (75 sec cycle) and 25th Street (120 sec cycle), as well as high eastbound traffic volumes. These two factors result in higher delays at the intersection of 27th Street/"O" Street, creating eastbound backups from 27th Street through the intersection of 25th Street. Detailed statistics presented in Appendix A show that the test vehicle was required to stop at both 25th Street and 27th Street and wait through two signal cycles before continuing eastbound, further illustrating the amount of delay experienced and the low average speed.

Normal Boulevard/Capitol Parkway/"K" & "L" Streets (9th Street to 56th Street)

Tables 8a and 8b summarize the results of the travel time studies conducted along the Normal Boulevard/Capitol Parkway/"K" & "L" Streets corridor. The limits of this corridor were defined by the intersection at 9th Street on the west and 56th Street on the east. This corridor traverses through the downtown area between 9th Street and 17th Street and continues through educational, commercial and residential land uses. Posted speed limits through the corridor are as follows:

- 9th Street to 17th Street = 30 mph
- 17th Street to 27th Street = 35 mph
- 27th Street to South Street = 40 mph
- South Street to 56th Street = 35 mph

Due to anticipated construction of a parking garage near "K" Street and "L" Street that would decrease street capacity and alter vehicle travel speeds with lane closures, "after" travel time studies for these two streets were conducted between 9th Street and 17th Street before signal timing adjustments could be made to signals east of 21st Street along Capitol Parkway/Normal Boulevard. Therefore, the corridor was divided into two parts, and the results of the "after" studies were combined to get an average speed and delay for the entire corridor. However, detailed statistics could not be calculated for the entire corridor, since the number of runs collected were not the same for each part of the corridor. Therefore, detailed statistics for both the "before" and "after travel time studies were calculated for each of the two parts with the results summarized in Tables 8c through 8f. Additional information for each of the two parts can be found in Appendix C.

In general, average delay along the corridor in both directions was maintained or decreased during all three time periods, with the exception of the westbound direction during the Midday time period, which increased from 85.0 sec/veh to 97.8 sec/veh. The most significant decrease in overall corridor delay was experienced during the PM Peak, decreasing by 77.0 sec/veh in the westbound direction. Table 9 summarizes the segments of the corridor that contribute the most considerably to the overall delay in each direction along the corridor.

Table 8a: "Before" Travel Time Studies-Normal Boulevard/Capitol Parkway/"K" & "L" Streets (9th Street to 56th Street)

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2: Day 3:	Tues., 4/2/02 Wed., 4/3/02 Thurs., 4/18/02		Tues., 4/2/02 Wed., 4/17/02		Tues., 4/2/02 Wed., 4/17/02 Fri., 4/19/02	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	598.1	560.7	577.8	487.3	657.2	626.5
Standard Deviation (sec/veh)	79.8	87.8	34.8	38.1	148.8	36.5
Average Number of Stops/veh	5.4	3.8	5.5	2.0	5.2	6.6
Average Delay (sec/veh)	**198.5**	**158.3**	**177.6**	**85.0**	**257.4**	**224.2**
Number of Runs	9	9	8	8	11	12
Length (feet)	20,763	20,912	20,786	20,902	20,770	20,905
Average Speed (mph)	23.7	25.4	24.5	29.2	21.5	22.8
Standard Deviation (mph)	2.8	3.7	1.5	2.4	4.7	1.3
95% Confidence Interval (mph)	1.8	2.4	1.0	1.7	2.8	0.7
Average Speed Within This Range (mph)[1] Lower Limit: Upper Limit	 21.9 25.5	 23.0 27.8	 23.5 25.5	 27.5 30.9	 18.7 24.3	 22.1 23.5
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	 116.8 146.4 298.6	 44.7 72.9 274.7	 75.4 109.3 281.9	 28.1 40.8 181.1	 114.9 156.5 378.3	 113.0 149.7 339.8

[1] Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: "K" & "L" Streets-9th Street to 17th Street = 30 mph
"K" & "L" Streets/Capitol Parkway-17th Street to 27th Street = 35 mph
Capitol Parkway-27th Street to South Street = 40 mph
Normal Boulevard-South Street to 56th Street = 35 mph

Ideal Travel Time = 399.7 seconds (6 min, 39.7 sec)

Table 8b: "After" Travel Time Studies-Normal Boulevard/Capitol Parkway/"K" & "L" Streets (9th Street to 56th Street)

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Part 1 - Day 1: Part 1 - Day 2: Part 2 – Day 1: Part 2 – Day 2:	Mon., 3/3/03 Wed., 3/5/03 Thurs., 4/17/03 Tues., 4/15/03		Mon., 3/3/03 Wed., 3/12/03 Thurs., 4/10/03 Wed. 4/9/03		Mon., 3/3/03 Wed., 3/12/03 Thurs., 4/10/03 Wed. 4/9/03	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	559.8	552.0	565.0	500.4	653.7	549.4
Standard Deviation (sec/veh)[2]	-	-	-	-	-	-
Average Number of Stops/veh	3.4	2.5	3.7	2.1	5.0	4.2
Average Delay (sec/veh)	**160.2**	**149.5**	**165.8**	**97.8**	**254.1**	**147.2**
Number of Runs	9/7	10/8	14/11	15/12	13/11	13/12
Length (feet)	20,765	20,915	20,743	20,919	20,760	20,900
Average Speed (mph)	25.3	25.8	25.0	28.5	21.7	25.9
Standard Deviation (mph)[2]	-	-	-	-	-	-
95% Confidence Interval (mph)[2]	-	-	-	-	-	-
Average Speed Within This Range (mph)[1, 2] Lower Limit: Upper Limit	 - -	 - -	 - -	 - -	 - -	 - -
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	 81.2 107.1 226.9	 61.3 88.2 252.7	 100.5 120.4 208.4	 42.2 55.0 170.6	 147.9 154.8 337.1	 70.8 95.6 226.3

[2] Since "after" travel time studies for this corridor were conducted in two separate portions, detailed statistics for the entire corridor could not be calculated due to differences in the number of runs performed for each portion of the corridor.

Notes: Part 1 – 9th Street to 17th Street
Part 2 – 17th Street to 56th Street

Table 8c: "Before" Travel Time Studies-Normal Boulevard/Capitol Parkway/"K" & "L" Streets (9th Street to 17th Street) – Part 1 Statistical Analysis

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Part 1 - Day 1: Part 1 - Day 2:	Mon., 3/3/03 Wed., 3/5/03		Mon., 3/3/03 Wed., 3/12/03		Mon., 3/3/03 Wed., 3/12/03	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	137.6	105.8	121.5	102.0	130.4	153.2
Standard Deviation (sec/veh)	7.1	22.1	10.6	22.9	17.7	21.8
Average Number of Stops/veh	2.0	0.3	1.7	0.1	1.3	1.6
Average Delay (sec/veh)	**64.5**	**32.6**	**48.0**	**28.7**	**57.1**	**79.7**
Number of Runs	9	9	8	8	11	12
Length (feet)	3,215	3,220	3,233	3,224	3,224	3,232
Average Speed (mph)	15.9	20.8	18.1	21.6	16.9	14.4
Standard Deviation (mph)	0.9	4.1	1.7	3.7	1.9	1.7
95% Confidence Interval (mph)	0.6	2.7	1.2	2.6	1.1	1.0
Average Speed Within This Range (mph)[1] Lower Limit: Upper Limit	 15.3 16.5	 18.1 23.5	 16.9 19.3	 19.0 24.2	 15.8 18.0	 13.4 15.4
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	 37.8 48.9 114.4	 10.7 12.2 94.1	 14.0 23.8 108.9	 6.6 7.6 95.0	 20.8 27.5 126.3	 39.9 48.3 150.4

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: "K" & "L" Streets-9th Street to 17th Street = 30 mph

Ideal Travel Time = 73.3 seconds (1 min, 13.3 sec)

Table 8d: "After" Travel Time Studies-Normal Boulevard/Capitol Parkway/"K" & "L" Streets (9th Street to 17th Street) – Part 1 Statistical Analysis

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Part 2 – Day 1: Part 2 – Day 2:	Thurs., 4/17/03 Tues., 4/15/03		Thurs., 4/10/03 Wed. 4/9/03		Thurs., 4/10/03 Wed. 4/9/03	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	136.3	96.9	103.6	99.3	125.6	149.6
Standard Deviation (sec/veh)	52.6	21.1	27.4	24.4	5.8	32.2
Average Number of Stops/veh	1.2	0.2	0.7	0.2	1.0	2.1
Average Delay (sec/veh)	**63.2**	**23.3**	**30.5**	**25.6**	**52.3**	**76.1**
Number of Runs	9	10	14	15	13	13
Length (feet)	3,223	3,239	3,213	3,244	3,228	3,235
Average Speed (mph)	16.1	22.8	21.2	22.3	17.5	14.7
Standard Deviation (mph)	6.1	4.2	6.6	1.2	0.8	2.1
95% Confidence Interval (mph)	4.0	2.6	3.5	2.3	0.4	2.7
Average Speed Within This Range (mph)[1] Lower Limit: Upper Limit	 12.1 20.1	 20.2 25.4	 17.7 24.6	 20.2 24.6	 17.1 18.0	 12.1 17.4
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	 41.3 49.6 97.0	 7.9 8.8 86.1	 21.0 23.6 55.2	 8.7 9.7 77.7	 35.2 41.0 96.2	 46.9 59.0 129.1

Table 8e: "Before" Travel Time Studies-Normal Boulevard/Capitol Parkway/"K" & "L" Streets (17th Street to 56th Street) – Part 2 Statistical Analysis

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Part 1 - Day 1: Part 1 - Day 2:	Mon., 3/3/03 Wed., 3/5/03		Mon., 3/3/03 Wed., 3/12/03		Mon., 3/3/03 Wed., 3/12/03	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	460.6	454.9	456.3	385.3	526.8	473.3
Standard Deviation (sec/veh)	79.9	78.7	34.0	32.5	135.9	26.2
Average Number of Stops/veh	3.4	3.4	3.8	1.9	3.9	5.0
Average Delay (sec/veh)	**134.0**	**125.7**	**129.6**	**56.3**	**200.3**	**144.5**
Number of Runs	9	10	14	15	12	12
Length (feet)	17,548	17,692	17,553	17,678	17,546	17,673
Average Speed (mph)	26.0	26.5	26.2	31.3	22.7	25.5
Standard Deviation (mph)	3.9	4.2	2.0	2.7	5.9	1.3
95% Confidence Interval (mph)	2.5	2.7	1.4	1.9	3.5	0.7
Average Speed Within This Range (mph)[1] Lower Limit: Upper Limit	 23.5 28.5	 23.8 29.2	 24.8 27.6	 29.4 33.2	 19.2 26.2	 24.8 26.2
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	 79.0 97.6 184.1	 34.0 60.7 180.6	 61.4 85.5 173.0	 21.5 33.1 86.1	 94.1 129.1 252.0	 73.1 101.4 189.3

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: "K" & "L" Streets/Capitol Parkway-17th Street to 27th Street = 35 mph
Capitol Parkway-27th Street to South Street = 40 mph
Normal Boulevard-South Street to 56th Street = 35 mph

Ideal Travel Time = 326.4 seconds (5 min, 26.4 sec)

Table 8f: "After" Travel Time Studies-Normal Boulevard/Capitol Parkway/"K" & "L" Streets (17th Street to 56th Street) – Part 2 Statistical Analysis

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Part 2 – Day 1: Part 2 – Day 2:	Thurs., 4/17/03 Tues., 4/15/03		Thurs., 4/10/03 Wed. 4/9/03		Thurs., 4/10/03 Wed. 4/9/03	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	423.4	455.1	461.5	401.1	528.1	399.8
Standard Deviation (sec/veh)	64.7	146.5	36.5	31.1	101.7	33.7
Average Number of Stops/veh	2.1	2.3	3.0	1.9	4.0	2.2
Average Delay (sec/veh)	**97.0**	**126.2**	**135.2**	**72.2**	**201.8**	**71.1**
Number of Runs	7	8	11	12	11	12
Length (feet)	17,542	17,676	17,530	17,675	17,532	17,665
Average Speed (mph)	28.2	26.5	25.9	30.0	22.6	30.1
Standard Deviation (mph)	4.3	7.0	2.1	2.5	4.3	2.5
95% Confidence Interval (mph)	3.2	4.9	1.2	1.4	2.6	1.4
Average Speed Within This Range (mph)[1,] Lower Limit: Upper Limit	 25.1 31.4	 21.6 31.4	 24.7 27.1	 28.7 31.4	 20.1 25.2	 28.7 31.5
Time Duration Below: (sec/veh) 0 mph 7 mph 28 mph	 39.9 57.6 129.9	 53.4 79.4 166.6	 79.5 96.7 153.2	 33.5 45.3 92.9	 112.6 113.8 240.9	 23.9 36.6 97.3

Table 9: Segments Contributing Considerably to Overall Delay – Normal Boulevard/Capitol Parkway/"K" & "L" Streets

Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Corridor Delay
AM Peak	Eastbound	9th Street – 10th Street	32.5	20%
		"J" Street – Randolph Street	18.3	11%
		52nd Street (Ped) – 56th Street	30.2	19%
	Westbound	52nd Street (Ped) – 48th Street	19.7	13%
		South Street – "A" Street	23.3	16%
		"A" Street – 27th Street	32.4	22%
Midday	Eastbound	"J" Street – Randolph Street	20.9	13%
		40th Street – 48th Street	40.0	24%
		52nd Street (Ped) – 56th Street	34.5	21%
PM Peak	Eastbound	9th Street – 10th Street	26.9	11%
		17th Street – 21st Street	38.1	15%
		"J" Street – Randolph Street	27.1	11%
		52nd Street (Ped) – 56th Street	66.3	26%
	Westbound	17th Street – 16th Street	24.2	16%
		11th Street – 10th Street	22.0	15%
		10th Street – 9th Street	20.0	14%

For the eastbound direction, increased delay was experienced between 9th Street and 10th Street and between 52nd Street (Pedestrian Crossing) and 56th Street, which are segments that are defined by downstream intersections with high traffic volumes that must compete for limited green time. Higher delays for the eastbound segment between "J" Street and Randolph Street during the three time periods were not unexpected. This segment represents the transition between different cycle lengths, thus interrupting coordination between traffic signals within the downtown area and the remaining corridor. This segment is also characterized by multiple curvatures in the roadway, which can also contribute to lower speeds and increased delay.

During the PM Peak, increased delay was experienced in the westbound direction for three segments within the downtown area. These increased delays were somewhat expected, based on the implemented timing plan. Between 17th Street and 16th Street, the implemented timing plan requires vehicles to stop at 16th Street in order to maintain progression along other major cross-streets. The considerable westbound delay between 11th Street and 10th Street and between 10th Street and 9th Street is due to limited green time available for westbound vehicles resulting from significantly higher traffic volumes on both 9th Street and 10th Street competing for a larger portion of the cycle length.

Superior Street (I-180 to Cornhusker Highway)

Tables 10a and 10b summarize the results of the travel time studies conducted along Superior Street. The limits of this corridor are defined by the I-180 West Ramps on the west and Cornhusker Highway on the east. This corridor is mostly characterized by commercial land uses, with a few residential areas interspersed. This corridor has a posted speed limit of 40 mph between the I-180 West Ramps and 27th Street, 45 mph between 27th Street and 48th Street, and 40 mph from 48th Street to Cornhusker Highway.

This corridor had been previously studied and signal timings adjusted during Fall 1998 as part of the first contract for this on-going project. In 1998, this area of Lincoln had not yet been fully developed and, therefore, traffic volumes were not as high or consistent as they were in 2002. Thus, some of the traffic signals along this corridor were programmed to operate under full actuation ("free"), which allowed the signals to respond to fluctuating traffic demands on all approaches without maintaining coordination with adjacent signals. Since 1998, this area of Lincoln has experienced a large amount of development, and traffic volumes have also significantly increased.

The signal timing plans developed for this corridor re-programmed all the traffic signals along this corridor to operate in coordination with each other to maximize vehicle progression along the corridor. This resulted in significant improvements in overall travel time and delay in both directions during all three peak time periods, with the most significant decreases in delay occurring in the westbound direction during the AM Peak (70.5 sec/veh) and eastbound direction during the Midday (72.5 sec/veh). Table 11 summarizes the segments of the corridor that contribute the most considerably to the overall delay in each direction along the corridor.

Table 10a: "Before" Travel Time Studies-Superior Street (I-180 to Cornhusker Highway)

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: / Day 2:	Mon., 4/8/02 / Wed., 4/17/02		Fri., 4/5/02 / Tues., 4/9/02		Fri., 4/5/02 / Thurs., 4/18/02	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	502.3	412.1	485.1	418.7	463.6	440.3
Standard Deviation (sec/veh)	31.2	14.4	45.0	43.3	41.8	25.9
Average Number of Stops/veh	4.0	2.1	2.8	2.4	3.2	4.0
Average Delay (sec/veh)	**179.2**	**88.6**	**162.5**	**95.4**	**141.6**	**117.8**
Number of Runs	8	8	10	10	9	10
Length (feet)	19,820	19,853	19,788	19,834	19,757	19,787
Average Speed (mph)	26.9	32.8	27.8	32.3	29.1	30.6
Standard Deviation (mph)	1.7	1.2	2.6	3.7	2.6	1.8
95% Confidence Interval (mph)	1.2	0.8	1.6	2.3	1.7	1.1
Average Speed Within This Range (mph)[1]						
Lower Limit:	25.7	32.0	26.2	30.0	27.4	29.5
Upper Limit	28.1	33.6	29.4	34.6	30.8	31.7
Time Duration Below: (sec/veh)						
0 mph	98.6	43.4	98.4	29.9	83.7	37.3
7 mph	123.8	56.0	120.6	44.1	104.9	64.1
28 mph	202.6	104.1	180.1	113.6	163.9	145.9

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: I-180 West Ramps to 27th Street = 40 mph
27th Street to 48th Street = 45 mph
48th Street to Cornhusker Highway = 40 mph

Ideal Travel Time = 323.6 seconds (5 min, 23.6 sec)

Table 10b: "After" Travel Time Studies-Superior Street (I-180 to Cornhusker Highway)

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: / Day 2:	Wed., 11/6/02 / Wed., 11/13/02		Wed., 11/6/02 / Tues., 11/12/02		Wed., 11/6/02 / Wed., 11/13/02	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	469.5	339.6	412.0	359.2	469.8	396.6
Standard Deviation (sec/veh)	45.8	8.1	59.4	35.1	40.5	51.4
Average Number of Stops/veh	3.0	0.3	2.3	0.3	2.3	0.7
Average Delay (sec/veh)	**148.9**	**18.1**	**90.0**	**36.8**	**147.8**	**73.4**
Number of Runs	8	8	12	11	10	11
Length (feet)	19,776	19,818	19,753	19,780	19,755	19,832
Average Speed (mph)	28.7	39.8	32.7	37.5	28.7	34.1
Standard Deviation (mph)	3.2	0.9	4.2	3.1	2.4	4.2
95% Confidence Interval (mph)	2.2	0.6	2.4	1.8	1.5	2.5
Average Speed Within This Range (mph)[1]						
Lower Limit:	26.5	39.2	30.3	35.7	27.2	31.6
Upper Limit	30.9	40.4	35.1	39.3	30.2	36.6
Time Duration Below: (sec/veh)						
0 mph	85.6	0.0	24.9	7.5	84.2	25.5
7 mph	103.4	1.6	39.7	10.0	100.9	30.3
28 mph	161.1	11.6	92.4	28.5	152.6	61.9

Table 11: Segments Contributing Considerably to Overall Delay – Superior Street

Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Corridor Delay
AM Peak	Eastbound	48th Street–Cornhusker Hwy	75.8	51%
Midday	Eastbound	20th Street – 27th Street 29th Street/Industrial Ave. – 33rd Street	22.3 20.6	25% 23%
	Westbound	29th Street/Industrial Ave. – 27th Street	11.0	30%
PM Peak	Eastbound	48th Street–Cornhusker Hwy	85.9	58%
	Westbound	29th Street/Industrial Ave. – 27th Street	30.9	42%

As expected, the segments that experienced a considerable portion of the overall delay are those links that are defined by a major intersection at the downstream end of the segment. At these intersections, approaches on Superior Street and the cross-street approaches are characterized by high traffic volumes. In addition to the high traffic volumes in all directions competing for green time, these volumes also dictate the need for additional signal phases, resulting in high intersection delay and low travel speeds.

Cornhusker Highway (11th Street to Superior Street/Havelock Avenue)

Tables 12a and 12b summarize the results of the travel time studies conducted along Cornhusker Highway. The limits of this corridor were defined by 11th Street on the west and Superior Street/Havelock Avenue on the east. This corridor is bordered by commercial land uses along its entire length, with areas further characterized by commercial "big box" type uses (e.g., Super Saver, Menards). Cornhusker Highway has posted speeds limits of 40 mph from 11th Street to 33rd Street and 45 mph between 33rd Street and Superior Street/Havelock Avenue.

This corridor was also previously studied and signal timings adjusted in Fall 1998 as part of the first contract for this on-going project. This area of Lincoln has also experienced a considerable amount of development, resulting in increased traffic volumes along this corridor.

The results of the "after" studies show that the overall corridor average delay decreased during all three time periods, with one exception. Between the "before" and "after" studies, the westbound direction during the AM Peak showed an increase in average delay of 9.3 sec/veh. The most significant decreases in overall corridor delay were observed for the westbound direction during the Midday, decreasing by 57.8 sec/veh, and for the eastbound direction during the PM Peak, decreasing by 61.2 sec/veh.

Upon further investigation of the detailed statistics of the "after" studies, it was observed that the average delay during the AM Peak in the eastbound direction for the segment between 11th Street and 20th Street was unexpectedly high. Further analysis of the individual runs associated with this link during the AM Peak showed that travel time data collected on Day 2 did not reflect the signal timing design for this direction. Reasons for the discrepancy in vehicle progression on Day 2 through this segment were investigated, but could not be explained. Therefore, additional calculations were performed for the entire corridor, excluding the data from Day 2. These calculations show an average delay of 36.4 seconds for the entire length of the corridor, which indicates a more considerable improvement in vehicle progression than is reported in Table 12b and is more representative of the signal timing design. Detailed statistics for the corridor based on eight runs and based on four runs for the eastbound direction during the AM Peak are provided in Appendix A.

Table 13 summarizes the segments of the corridor that contribute the most considerably to the overall delay in each direction along the corridor. The remaining corridor delay is more evenly distributed among the remaining segments.

Table 12a: "Before" Travel Time Studies-Cornhusker Highway (11th Street to Superior Street/Havelock Avenue)

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2:	Tues., 4/9/02 Fri., 4/12/02		Mon., 4/8/02 Fri., 4/12/02		Mon., 4/8/02 Fri., 4/12/02	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	440.8	378.6	408.1	469.4	463.6	473.9
Standard Deviation (sec/veh)	19.2	52.0	55.3	79.8	19.7	57.2
Average Number of Stops/veh	2.9	1.5	2.0	2.9	2.6	3.1
Average Delay (sec/veh)	**128.5**	**64.4**	**92.5**	**155.1**	**148.1**	**159.6**
Number of Runs	8	8	9	10	9	9
Length (feet)	19,600	19,524	19,621	19,557	19,608	19,529
Average Speed (mph)	30.3	35.2	32.8	28.4	28.8	28.1
Standard Deviation (mph)	1.3	4.5	4.5	4.5	1.2	3.6
95% Confidence Interval (mph)	0.9	3.1	2.9	2.8	0.8	2.4
Average Speed Within This Range (mph)[1]						
Lower Limit:	29.4	32.1	29.9	25.6	28.0	25.7
Upper Limit	31.2	38.3	35.7	31.2	29.6	30.5
Time Duration Below: (sec/veh)						
0 mph	78.9	37.4	40.8	85.9	80.9	90.1
7 mph	98.1	45.5	53.2	108.7	98.6	109.3
28 mph	146.9	73.9	106.3	177.3	158.6	173.2

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: 11th Street to 33rd Street = 40 mph
33rd Street to Superior Street/Havelock Avenue = 45 mph

Ideal Travel Time = 315.3 seconds (5 min, 15.3 sec)

Table 12b: "After" Travel Time Studies-Cornhusker Highway (11th Street to Superior Street/Havelock Avenue)

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2:	Tues., 11/5/02 Tues., 11/12/02		Tues., 11/5/02 Wed., 11/13/02		Tues., 11/5/02 Tues., 11/12/02	
Travel Time Statistic	EB	WB	EB	WB	EB	WB
Average Travel Time (sec/veh)	393.9	388.3	369.3	411.5	401.9	457.3
Standard Deviation (sec/veh)	56.2	50.1	55.6	53.6	54.0	68.2
Average Number of Stops/veh	0.8	0.5	0.6	1.3	1.2	1.4
Average Delay (sec/veh)	**78.3**	**73.7**	**54.2**	**97.3**	**86.9**	**143.1**
Number of Runs	8	8	11	11	9	10
Length (feet)	19,612	19,546	19,581	19,523	19,581	19,526
Average Speed (mph)	33.9	34.3	36.2	32.4	33.2	29.1
Standard Deviation (mph)	4.7	4.5	4.4	4.0	5.0	4.6
95% Confidence Interval (mph)	3.3	3.1	2.6	2.4	3.3	2.9
Average Speed Within This Range (mph)[1]						
Lower Limit:	30.6	31.2	33.6	30.0	29.9	26.2
Upper Limit	37.2	37.4	38.8	34.8	36.5	32.0
Time Duration Below: (sec/veh)						
0 mph	38.3	29.4	17.5	48.5	47.8	69.2
7 mph	44.0	33.4	21.8	55.7	53.9	81.4
28 mph	70.5	62.0	45.5	91.3	85.9	143.7

Table 13: Segments Contributing Considerably to Overall Delay–Cornhusker Highway

Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Corridor Delay
AM Peak	Westbound	29th Street/State Fair Park Road – 27th Street	31.8	43%
Midday	Westbound	20th Street – 11th Street	53.6	55%
PM Peak	Eastbound	48th Street – Superior Street/ Havelock Avenue	39.2	45%
	Westbound	29th Street/State Fair Park Road – 27th Street	34.5	24%
		20th Street – 11th Street	49.6	35%

As expected, the segments that experienced a considerable portion of the overall delay are those links that are defined by a major intersection at the downstream end of the segment. At these intersections, approaches on Cornhusker Highway and the cross-street approaches are characterized by high traffic volumes. In addition to the high traffic volumes in all directions competing for green time, these volumes also dictate the need for additional signal phases, resulting in high intersection delay and low travel speeds.

North 27th Street ("O" Street to Kensington Drive)

Table 14a and 14b summarize the results of the travel time studies conducted along North 27th Street. The limits of this corridor were defined by "O" Street on the south and Kensington Drive on the north. For a majority of its length, this corridor is characterized by commercial land uses. Between Cornhusker Highway and Kensington Drive, it is further characterized by commercial "big box" type uses (e.g., Menards, Shopko, WalMart). North 27th Street has a posted speed limit of 35 mph between "O" Street and Fair Street, 40 mph between Fair Street and Cornhusker Highway and 45 mph from Cornhusker Highway to Kensington Drive.

This corridor had been previously studied and signal timings adjusted in 2000 as part of the most recent contract for this on-going project. Due to the proximity and intricate relationship of this corridor to other study corridors, it was decided to include North 27th Street in this project. Since this corridor was recently studied, results of the "after" studies from the previous contract were used as the "before" study results in making comparisons to the "after" study results for this contract.

"After" study results shown in Table 14b indicate average delays along the corridor decreased during all three peak time periods. Table 15 summarizes the segments of the corridor that contribute the most considerably to the overall delay in each direction along the corridor. The remaining corridor delay is more evenly distributed among the remaining segments.

Table 14a: "Before" Travel Time Studies-North 27th Street ("O" Street to Kensington Drive)

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2: Day 3:	Tues., 10/10/00 Wed., 10/11/00 Mon., 11/20/00		Tues., 10/10/00 Wed., 10/11/00		Tues., 10/10/00 Wed., 10/11/00	
Travel Time Statistic	NB	SB	NB	SB	NB	SB
Average Travel Time (sec/veh)	420.8	449.3	452.1	473.2	496.9	573.5
Standard Deviation (sec/veh)	57.6	35.7	33.0	34.5	54.0	58.3
Average Number of Stops/veh	1.6	3.4	2.8	4.4	3.7	5.7
Average Delay (sec/veh)	**116.9**	**145.7**	**148.5**	**169.5**	**193.5**	**269.9**
Number of Runs	10	9	8	9	8	8
Length (feet)	17,687	17,668	17,671	17,676	17,655	17,671
Average Speed (mph)	28.7	26.8	26.6	25.5	24.2	21.0
Standard Deviation (mph)	3.7	2.2	1.9	1.9	2.8	2.1
95% Confidence Interval (mph)	2.3	1.4	1.3	1.2	1.9	1.5
Average Speed Within This Range (mph)[1]						
Lower Limit:	26.4	25.4	25.3	24.3	22.3	19.5
Upper Limit	31.0	28.2	27.9	26.7	26.1	22.5
Time Duration Below: (sec/veh)						
0 mph	82.1	77.0	78.4	77.7	112.7	138.7
7 mph	89.5	92.9	96.0	101.3	132.8	178.1
28 mph	136.3	179.3	173.6	204.7	224.7	326.2

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: "O" Street to Fair Street = 35 mph
Fair Street to Cornhusker Highway = 40 mph
Cornhusker Highway to Kensington Drive = 45 mph

Ideal Travel Time = 303.9 seconds (5 min, 3.9 sec)

"Before" travel time study results were calculated from "after" travel time data collected in Fall 2000 as part of the previous contract.

Table 14b: "After" Travel Time Studies-North 27th Street ("O" Street to Kensington Drive)

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: Day 2:	Wed., 4/2/03 Thurs., 4/3/03		Wed., 4/2/03 Thurs., 4/3/03		Wed., 4/2/03 Fri., 4/4/03	
Travel Time Statistic	NB	SB	NB	SB	NB	SB
Average Travel Time (sec/veh)	403.6	431.7	427.9	435.0	491.0	571.0
Standard Deviation (sec/veh)	32.3	78.9	62.6	64.1	31.5	64.4
Average Number of Stops/veh	2.1	1.7	2.5	2.4	3.4	4.8
Average Delay (sec/veh)	**100.1**	**128.3**	**124.4**	**131.9**	**188.2**	**267.7**
Number of Runs	9	9	12	12	10	10
Length (feet)	17,658	17,659	17,663	17,639	17,648	17,655
Average Speed (mph)	29.8	27.9	28.1	27.6	24.5	21.1
Standard Deviation (mph)	2.5	4.9	4.1	4.2	1.5	2.3
95% Confidence Interval (mph)	1.6	3.2	2.3	2.4	0.9	1.4
Average Speed Within This Range (mph)[1]						
Lower Limit:	28.2	24.7	25.8	25.2	23.6	19.7
Upper Limit	31.4	31.1	30.4	30.0	25.4	22.5
Time Duration Below: (sec/veh)						
0 mph	35.2	38.7	44.6	57.8	82.7	137.5
7 mph	48.4	50.2	60.9	71.1	108.7	171.5
28 mph	106.6	160.3	138.3	159.9	212.7	332.2

Table 15: Segments Contributing Considerably to Overall Delay – North 27th Street

Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Corridor Delay
AM Peak	Northbound	Fair Street – Cornhusker Highway	48.4	48%
	Southbound	Ticonderoga Drive – Superior Street Kmart Drive – Cornhusker Hwy Fair Street – Holdrege Street	28.0 20.3 25.1	22% 16% 20%
Midday	Northbound	Fair Street – Cornhusker Highway Cornhusker Hwy – Kmart Drive Fairfield Street – Superior Street	27.4 20.8 28.8	22% 17% 23%
	Southbound	Ticonderoga Drive – Superior Street Kmart Drive – Cornhusker Hwy "P" Street – "O" Street	24.3 21.5 34.5	18% 16% 26%
PM Peak	Northbound	Fair Street - Cornhusker Hwy Fairfield Street – Superior Street	70.7 36.2	38% 19%
	Southbound	Ticonderoga Drive – Superior Street Fair Street – Holdrege Street Vine Street – "P" Street "P" Street – "O" Street	42.3 32.4 38.8 65.7	16% 12% 14% 22%

As expected, the segments that experienced a considerable portion of the overall delay are those links that are defined by a major intersection at the downstream end of the segment. At these intersections, approaches on 27th Street and the cross-street approaches are characterized by high traffic volumes. In addition to the high traffic volumes in all directions competing for green time, these volumes also dictate the need for additional signal phases, resulting in high intersection delay and low travel speeds.

During the Midday, the northbound segment between Cornhusker Highway and Kmart Drive also experiences a higher proportion of the overall corridor delay. The higher proportion of delay is not entirely unexpected. The relative location of the intersection at Kmart Drive in relation to adjacent intersections creates difficulties in maintaining the most optimum progression along North 27th Street within this segment. In addition, Kmart drive services two major commercial areas that generate a significant amount of traffic, thus creating the need for additional left-turn phases on 27th Street and reducing green time availability for north-south through traffic.

The higher proportion of overall corridor delay experienced in the southbound direction for the segment between Fair Street and Holdrege Street can also be attributed to the difference in cycle lengths between Cornhusker Highway and Fair Street, which results in a lack of signal coordination and an interruption in vehicle progression. Since Fair Street carries a low volume of vehicles, a large amount of green time is given to North 27th Street at this intersection. Therefore, vehicles do not experience a noticeable amount of delay and lower speeds until they proceed through Fair Street and reach the major intersection at Holdrege Street, resulting in higher delays for this segment. The difference in cycle lengths also results in higher delays in the northbound direction between Fair Street and Cornhusker Highway.

South 27th Street (Van Dorn Street to "O" Street)

Tables 16a and 16b summarize the results of the travel time studies conducted along South 27th Street. The limits of this corridor were defined by Van Dorn Street on the south and "O" Street on the north. This portion of 27th Street is characterized by both residential and commercial land uses. The posted speed limit for this corridor is 35 mph along its entire length.

Both increases and decreases in average delay for the overall corridor were observed between the "before" and "after" studies. The most significant increase in average delay occurred in the northbound direction during the Midday time period, increasing by 81.6 sec/veh. An increase of 13.8 sec/veh was also observed in the northbound direction during the AM Peak.

Further analysis of the northbound direction during the Midday indicated that the test vehicle experienced unexpected stops and delays at the intersections of Sheridan Boulevard, South Street and Randolph Street. Therefore, adjustments were made to the signal timings at the intersections of Van Dorn Street, Sheridan Boulevard, Randolph Street and "J" Street to improve the average travel time along the corridor. However, additional travel time runs to measure the improvement in average travel time were not conducted since area schools and universities were not in session and other nearby arterials were closed for construction, affecting "normal" traffic patterns. Since additional "after" studies could not be conducted, analysis of the corridor was performed using arterial analysis methodologies outlined in the 2000 HCM to illustrate the potential improvement from these timing adjustments. Analysis of the corridor *before* and *after* these specific timing adjustments were made show that the northbound average delay would improve by 15.7 sec/veh and the southbound average delay would improve by 15.8 sec/veh. Therefore, it is expected that actual average travel time and delay along the corridor during the Midday will decrease as compared to the "after" travel time study results.

All other directions during the three peak time periods showed decreases in average delay. Table 17 summarizes the segments of the corridor that contribute the most considerably to the overall delay in each direction along the corridor. The remaining corridor delay is more evenly distributed among the remaining segments.

Table 16a: "Before" Travel Time Studies-South 27th Street (Van Dorn Street to "O" Street)

"BEFORE"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: / Day 2:	Mon., 11/4/02 / Fri., 11/8/02		Mon., 11/4/02 / Thurs., 11/7/02		Mon., 11/4/02 / Thurs., 11/7/02	
Travel Time Statistic	NB	SB	NB	SB	NB	SB
Average Travel Time (sec/veh)	285.2	360.9	281.2	278.8	415.1	345.5
Standard Deviation (sec/veh)	83.2	20.3	35.5	21.1	52.5	65.2
Average Number of Stops/veh	2.1	2.8	1.9	2.3	3.1	3.0
Average Delay (sec/veh)	**80.0**	**156.2**	**76.2**	**74.1**	**209.9**	**141.0**
Number of Runs	8	9	15	16	10	11
Length (feet)	10,539	10,509	10,542	10,503	10,535	10,498
Average Speed (mph)	25.2	19.9	25.6	25.7	17.3	20.7
Standard Deviation (mph)	5.6	1.2	3.4	2.0	2.1	4.3
95% Confidence Interval (mph)	3.9	0.8	1.7	1.0	1.3	2.5
Average Speed Within This Range (mph)[1]						
Lower Limit:	21.3	19.1	23.9	24.7	16.0	18.2
Upper Limit	29.1	20.7	27.3	26.7	18.6	23.2
Time Duration Below: (sec/veh)						
0 mph	38.3	107.3	39.9	22.9	132.5	55.3
7 mph	52.9	121.3	50.7	34.7	159.4	78.6
28 mph	109.9	191.0	99.1	111.2	257.8	208.7

[1]Limits of the range of average speed calculated based on the 95% confidence interval.

Notes: Posted Speed Limit: Van Dorn Street to "O" Street = 35 mph

Ideal Travel Time = 205.3 seconds (3 min, 25.3 sec)

Table 16b: "After" Travel Time Studies-South 27th Street (Van Dorn Street to "O" Street)

"AFTER"	AM Peak 7:00 AM – 8:30 AM		Midday 11:00 AM – 1:00 PM		PM Peak 4:00 PM – 6:00 PM	
Date of Study Day 1: / Day 2:	Mon., 4/14/03 / Wed., 4/16/03		Mon., 4/14/03 / Tues., 4/15/03		Fri., 4/11/03 / Tues., 4/15/03	
Travel Time Statistic	NB	SB	NB	SB	NB	SB
Average Travel Time (sec/veh)	298.6	330.5	363.0	268.1	396.1	335.5
Standard Deviation (sec/veh)	58.7	47.3	57.9	62.2	66.9	38.5
Average Number of Stops/veh	1.6	3.5	4.1	1.1	4.5	2.8
Average Delay (sec/veh)	**93.8**	**125.7**	**157.8**	**63.6**	**191.7**	**131.0**
Number of Runs	11	11	15	14	13	12
Length (feet)	10,544	10,510	10,534	10,495	10,530	10,499
Average Speed (mph)	24.1	21.7	19.8	26.7	18.1	21.3
Standard Deviation (mph)	5.7	3.2	3.8	5.7	3.4	3.0
95% Confidence Interval (mph)	3.4	1.9	1.9	3.0	1.8	1.7
Average Speed Within This Range (mph)[1]						
Lower Limit:	20.7	19.8	17.9	23.7	16.3	19.6
Upper Limit	27.5	23.6	21.7	29.7	19.9	23.0
Time Duration Below: (sec/veh)						
0 mph	54.5	58.7	88.6	27.1	123.1	50.7
7 mph	63.8	80.2	116.3	33.3	150.7	68.3
28 mph	125.5	168.9	209.1	91.2	238.2	198.1

Table 17: Segments Contributing Considerably to Overall Delay – South 27th Street

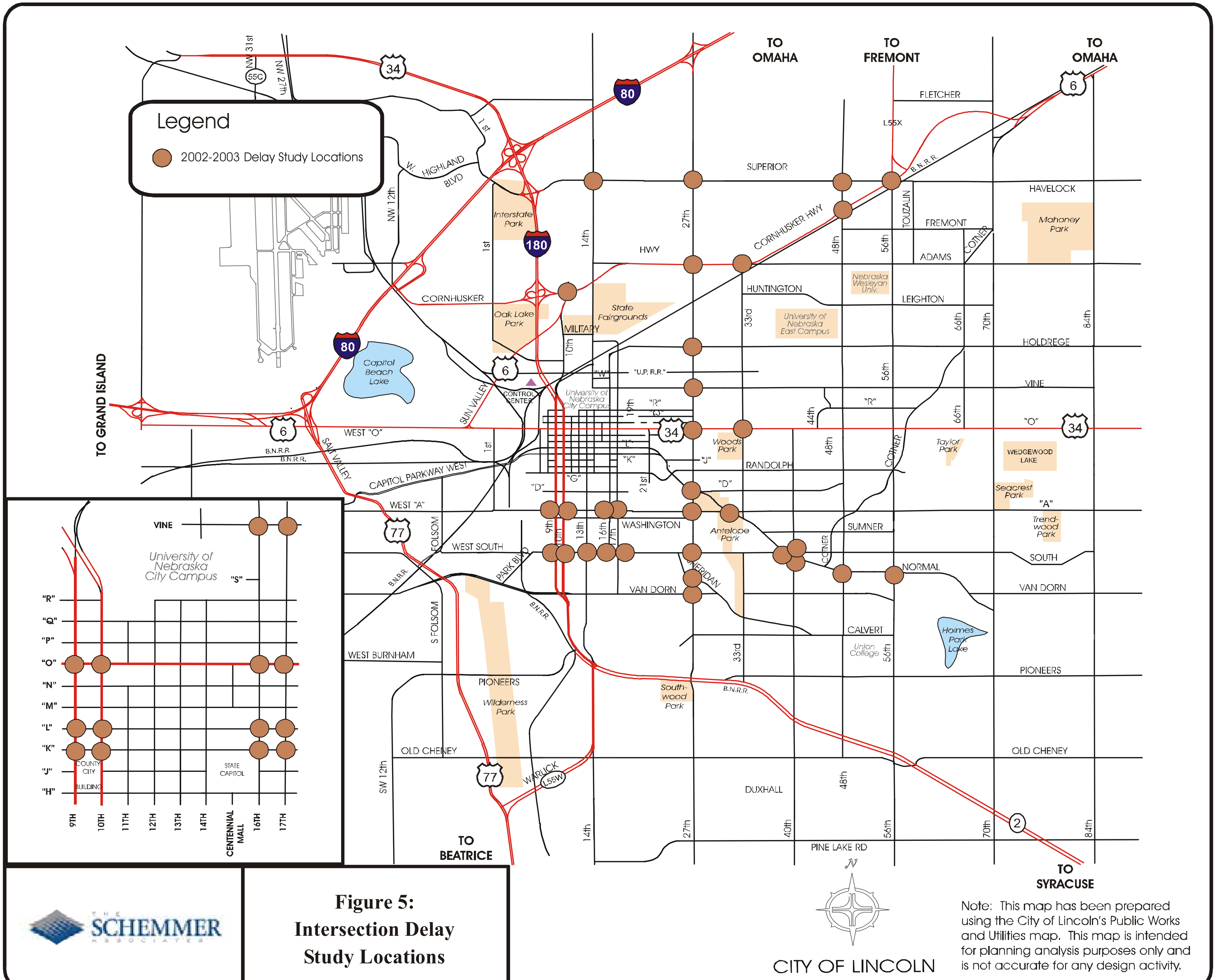
Time Period	Direction	Link	Average Delay (sec/veh)	% of Overall Corridor Delay
AM Peak	Northbound	"A" Street – Capitol Parkway	38.4	41%
	Southbound	Randolph Street – Capitol Parkway Capitol Parkway – "A" Street	42.3 29.4	34% 23%
Midday	Northbound	Sheridan Boulevard – South Street "A" Street – Capitol Parkway "M" Street (Ped) – "O" Street	29.7 42.4 40.0	19% 27% 25%
PM Peak	Northbound	"A" Street – Capitol Parkway "M" Street (Ped) – "O" Street	62.0 51.6	32% 27%
	Southbound	Randolph Street – Capitol Parkway	68.6	52%

Similar to North 27th Street, the segments that experienced a higher proportion of the overall corridor delay are those links that are defined by a major intersection at the downstream end of the segment. At these intersections, approaches on South 27th Street and the cross-street approaches are characterized by high traffic volumes. In addition to the high traffic volumes in all directions competing for green time, these volumes also dictate the need for additional signal phases, resulting in high intersection delay and low travel speeds. During the AM Peak, the southbound direction between Capitol Parkway and "A" Street also experiences considerable delay. This is not unexpected based on the implemented signal timing plan, which was designed to maintain better progression in the northbound direction during the AM Peak for this segment, since northbound volumes are significantly higher than southbound. The northbound direction does, however, continue to experience higher delays, which is most likely attributable to the limited amount of green time available at the intersection of 27th Street/Capitol Parkway.

Intersection Delay Studies

In addition to conducting travel time studies, intersection delay studies were conducted to evaluate the changes in operational performance due to signal timing modifications. While travel time studies are beneficial in assessing how well signal timings are coordinated between intersections and whether or not vehicles can progress through a series of intersections without being stopped, delay studies measure the average amount of time vehicles are stopped, or delayed, at signalized intersections. Furthermore, where travel time studies evaluate the performance of operations along the specific corridor, delay studies also measure vehicle delays on the cross-street approaches.

Stopped-vehicle delay was measured at 46 signalized intersections, as shown in Figure 5, by conducting stopped delay studies during the AM Peak, Midday and PM Peak time periods, both "before" and "after" new signal timings were implemented.



Note: This map has been prepared using the City of Lincoln's Public Works and Utilities map. This map is intended for planning analysis purposes only and is not accurate for any design activity.

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Figure 5: Intersection Delay Study Locations

Delay studies were conducted within the peak one-hour of each study time period on days experiencing "average" traffic conditions. At each of these intersections, the average amount of stopped time each vehicle/driver experienced was estimated by counting the number of vehicles observed as "stopped" at 13-second intervals, for each approach of the intersection. By making the assumption that each vehicle was stopped for the entire 13-second interval, the number of observed vehicles is multiplied by 13 seconds to obtain the total amount of intersection delay. This number is then divided by the total traffic volume to determine the average delay per vehicle for the entire intersection.

Delay is a complex measure and is dependent on a number of variables, including quality of progression, traffic volumes, signal timing parameters and intersection capacity. Another way of expressing delay is in the form of level-of-service (LOS). Specifically, LOS criteria are stated in terms of the average delay per vehicle.

It should be noted that the vehicle delay measured in the field is termed *stopped vehicle delay*, and represents the amount of time a vehicle is stopped at an intersection. This is the type of delay utilized by the 1994 *Highway Capacity Manual* (HCM). Recent revisions to this document, beginning with the 1997 version and most recently, the 2000 version, have used *control delay* to identify the LOS intersections are operating under. Control delay is the portion of the total delay attributed to traffic signal operation for signalized intersections. The LOS criteria for stopped delay and control delay are summarized in Table 18.

Table 18: Level-of-Service Criteria (Signalized Intersections)

Level-of-Service	1994 Highway Capacity Manual Stopped Delay/Vehicle (sec)	2000 Highway Capacity Manual Control Delay/Vehicle (sec)
A	≤ 5	≤ 10
B	> 5 and ≤ 15	> 10 and ≤ 20
C	> 15 and ≤ 25	> 20 and ≤ 35
D	> 25 and ≤ 40	> 35 and ≤ 55
E	> 40 and ≤ 60	> 55 and ≤ 80
F	> 60	> 80

Control delay includes initial deceleration delay, queue move-up time, stopped delay and final acceleration delay. According to the 2000 HCM, control delay is approximately 30% greater than stopped delay. Since it is difficult to measure control delay in the field for every vehicle approaching an intersection, stopped delay was measured, as outlined in ITE's *Manual of Transportation Engineering Studies*, multiplied by 1.3, and cross-referenced to Table 18 to identify what LOS the intersection is operating under per the 2000 HCM criteria. Throughout the remainder of this chapter, references to intersection LOS pertain to the 2000 HCM criteria.

Reasons for different improvements in intersection delay versus average travel-speed on study corridors are twofold. One, when performing the traffic signal optimization analysis, attention was given to the intersection approaches on the study corridors as well as the approaches of the cross-streets. Therefore, many of the reductions in intersection delay are a result of decreases in delay on all four approaches to the intersection and not just the two approaches pertaining to the study corridors. These improvements for cross-street traffic are not represented in the analysis of the travel-time corridors. The second reason for the greater improvements in intersection delay relates to the sub-system analysis. Many of the increases in average travel time are a result of increased delays at the intersections where sub-systems are broken. The remaining intersections are experiencing efficient operation in terms of both signal timings and progression, which result in lower delays.

The following sections summarize the results of the "before" and "after" intersection delay studies conducted at locations along each of the eight corridors. Please note that the results are summarized in terms of control delay, as it relates to LOS. Detailed "before" and "after" intersection stopped-delay summaries for each intersection are provided in Appendix D. Dates when intersection delay studies were conducted are also provided in Appendix D.

9th/10th Streets

Intersection delay studies were conducted at eight (8) signalized intersections along 9th and 10th Streets and are summarized in Tables 19 and 20. Delay and LOS are reported for the overall intersection as well as for each individual approach for each of the three peak time periods.

Along 9th Street, most of the intersections show an improvement in the overall LOS and/or delay during each of the three peak time periods. During the AM Peak, only the intersection of 9th Street/South Street experienced an increase in delay from 10.3 sec/veh (LOS 'B') to 13.8 sec/veh (LOS 'B'). During the PM Peak, both the intersections of 9th Street/"L" Street and 9th Street/South Street showed improvements in LOS from 'B' to 'A'. However, 9th Street/"A" Street experienced an increase in delay from 5.1 sec/veh (LOS 'A') to 10.7 sec/veh (LOS 'B').

Overall, along 10th Street, most of the intersections maintained either LOS 'A' or 'B' during each of the three time periods. Only the intersection of 10th Street/South Street showed a decrease in LOS from 'A' to 'B' during each of the three time periods. However, the decrease in LOS is accompanied by only slight increases in overall intersection delay.

Table 19: Intersection Delay Studies – 9th Street

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
"L" Street	**Overall**	**3.9**	**A**	**3.5**	**A**	**2.3**	**A**	**1.4**	**A**	**13.9**	**B**	**7.8**	**A**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	3.1	A	0.0	A	2.2	A	0.3	A	7.8	A	1.0	A
	EB	-	-	-	-	-	-	-	-	-	-	-	-
	WB	7.7	A	17.0	B	3.0	A	7.0	A	30.6	C	28.6	C
"K" Street	**Overall**	**19.9**	**B**	**14.6**	**B**	**6.0**	**A**	**6.4**	**A**	**6.9**	**A**	**5.5**	**A**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	7.0	A	3.0	A	4.0	A	2.3	A	3.1	A	2.3	A
	EB	39.0	D	33.4	C	14.2	B	23.3	C	21.3	C	17.7	B
	WB	-	-	-	-	-	-	-	-	-	-	-	-
"A" Street	**Overall**	**12.7**	**B**	**9.9**	**A**	**7.0**	**A**	**3.3**	**A**	**5.1**	**A**	**10.7**	**B**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	11.6	B	9.6	A	0.8	A	1.6	A	0.9	A	10.9	B
	EB	9.0	A	14.3	B	17.7	B	12.7	B	17.6	B	12.0	B
	WB	23.8	C	3.6	A	32.4	C	9.6	A	23.1	C	7.0	A
South Street	**Overall**	**10.3**	**B**	**13.8**	**B**	**7.7**	**A**	**7.8**	**A**	**12.4**	**B**	**9.9**	**A**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	4.0	A	7.4	A	4.9	A	3.6	A	8.2	A	4.9	A
	EB	12.5	B	22.0	C	14.6	B	17.9	B	20.2	C	23.3	C
	WB	25.5	C	25.5	C	12.9	B	14.6	B	27.7	C	23.0	C

Table 20: Intersection Delay Studies – 10th Street

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
South Street	**Overall**	**9.6**	**A**	**10.5**	**B**	**8.3**	**A**	**12.2**	**B**	**10.0**	**A**	**11.8**	**B**
	NB	8.5	A	2.5	A	2.5	A	1.2	A	1.2	A	2.3	A
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	17.6	B	32.9	C	14.3	B	30.2	C	16.1	B	26.4	C
	WB	4.3	A	19.9	B	14.4	B	15.3	B	20.5	B	15.5	B
"A" Street	**Overall**	**9.1**	**A**	**8.2**	**A**	**8.9**	**A**	**9.4**	**A**	**16.4**	**B**	**9.5**	**A**
	NB	8.7	A	5.3	A	4.8	A	6.0	A	5.1	A	5.3	B
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	9.4	A	19.0	B	9.5	A	17.6	B	44.6	D	4.4	A
	WB	12.6	B	18.5	B	27.2	C	27.2	C	26.8	C	25.9	C
"K" Street	**Overall**	**11.8**	**B**	**12.0**	**B**	**12.1**	**B**	**7.5**	**A**	**19.4**	**B**	**9.6**	**A**
	NB	6.2	A	9.6	A	9.4	A	2.1	A	19.5	B	2.1	A
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	20.0	B	15.2	B	15.7	B	15.5	B	19.0	B	19.5	B
	WB	-	-	-	-	-	-	-	-	-	-	-	-
"L" Street[1]	**Overall**	**2.9**	**A**	**9.5**	**A**	**7.9**	**A**	**8.3**	**A**	**17.0**	**B**	**14.7**	**B**
	NB	3.5	A	12.0	B	11.4	B	11.4	B	27.0	C	6.1	A
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	-	-	-	-	-	-	-	-	-	-	-	-
	WB	1.8	A	4.6	A	1.3	A	1.7	A	7.2	A	23.1	C

[1]Northbound west lane was closed during the "after" studies due to construction in the area.
Therefore, an increase in approach or overall intersection delay is possible due to a restriction in the number of lanes that vehicles can use.

16th/17th Streets

Intersection delay studies were conducted at ten (10) signalized locations along 16th and 17th Streets. Delay studies were also conducted at the intersection of 13th Street/South Street, which was identified in the Focus Area Analysis. Tables 21 and 22 summarize the results of both the "before" and "after" intersection delay studies. Delay and LOS are reported for the overall intersection as well as for each individual approach for each of the three peak time periods.

Along 16th Street, the intersection of 16th Street/Vine Street showed the most improvement in overall intersection LOS during each of the three time periods, improving from LOS 'C' to LOS 'B'. During the AM Peak and Midday time periods, all other intersections along 16th Street remained at LOS 'B' or better, with the most significant increase in delay occurring at the intersection of 16th Street/"K" Street. This increase, however, was expected due to the changes that were made in signal timing progression within the downtown area. During the PM Peak, "before" LOS was either maintained or improved at all locations, with the exception of 16th Street/"L" Street. This decrease from LOS 'A' (7.0 sec/veh) to LOS 'C' (26.3 sec/veh) was also expected due to changes in signal timing coordination within the downtown area.

The intersection of 13th Street/South Street maintained LOS 'B' during the AM Peak and LOS 'A' during the Midday, with only slight increases in overall intersection delay. During the PM peak the intersection improved overall intersection delay from 33.7 sec/veh to 25.5 sec/veh, maintaining LOS 'C'.

During the AM Peak, the intersections at "A" Street, "K" Street and "L" Street along 17th Street all experienced slight increases in overall intersection delay, but maintained LOS 'B' or better. The intersection of 17th Street/Vine Street experienced improved overall delay. At 17th Street/South Street, intersection delay increased from 19.1 sec/veh (LOS 'B') to 22.1 sec/veh (LOS 'C'). This increase is due to the difference in cycle length between this intersection and other intersections along South Street east of 17th Street. Since the cycle lengths are different, the arrival of westbound vehicles is more random and coordination with traffic signals east of 17th Street is not possible.

During the Midday, all intersections along 17th Street improved to or maintained LOS 'B' or better. During the PM Peak, the intersection of 17th Street/Vine Street improved from 17.3 sec/veh to 11.3 sec/veh. All other intersections maintained LOS 'B' or better during the PM Peak.

Table 21: Intersection Delay Studies – 16th Street

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
Vine Street	**Overall**	**20.2**	**C**	**17.8**	**B**	**20.8**	**C**	**17.2**	**B**	**27.7**	**C**	**17.6**	**B**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	21.2	C	12.1	B	16.5	B	16.0	B	25.5	C	15.9	B
	EB	23.5	C	33.0	C	56.2	E	32.6	C	28.2	C	27.9	C
	WB	17.0	B	18.2	B	7.5	A	9.4	A	30.6	C	13.3	B
"L" Street	**Overall**	**3.6**	**A**	**3.8**	**A**	**4.3**	**A**	**4.0**	**A**	**7.0**	**A**	**26.3**	**C**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	4.9	A	3.6	A	2.7	A	5.5	A	6.0	A	23.4	C
	EB	-	-	-	-	-	-	-	-	-	-	-	-
	WB	2.9	A	3.8	A	6.8	A	2.1	A	9.1	A	31.9	B
"K" Street	**Overall**	**0.9**	**A**	**8.6**	**A**	**1.6**	**A**	**12.1**	**B**	**11.6**	**B**	**9.8**	**A**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	2.2	A	20.3	C	1.0	A	25.1	C	10.5	B	9.8	A
	EB	0.5	A	3.6	A	2.1	A	0.7	A	12.6	B	9.6	A
	WB	-	-	-	-	-	-	-	-	-	-	-	-
"A" Street	**Overall**	**15.2**	**B**	**13.8**	**B**	**6.6**	**A**	**11.8**	**B**	**12.7**	**B**	**16.8**	**B**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	4.2	A	3.1	A	3.4	A	1.4	A	11.8	B	2.9	A
	EB	18.5	B	14.8	B	5.7	A	12.5	B	12.4	B	39.1	D
	WB	22.6	C	25.7	C	12.2	B	33.4	C	16.5	B	38.1	D

Table 21: Intersection Delay Studies – 16th Street (cont'd)

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
South Street	**Overall**	**12.2**	**B**	**13.8**	**B**	**13.7**	**B**	**14.4**	**B**	**35.5**	**D**	**32.1**	**C**
	NB	45.1	D	32.1	C	29.1	C	42.1	D	61.2	E	50.1	D
	SB	20.2	C	6.6	A	18.9	B	10.9	B	64.9	E	23.9	C
	EB	4.9	A	11.6	B	7.9	A	11.4	B	13.0	B	47.5	D
	WB	12.7	B	19.1	B	10.8	B	9.8	A	14.0	B	12.7	B
13th Street/ South Street	**Overall**	**13.5**	**B**	**13.9**	**B**	**8.6**	**A**	**10.0**	**A**	**33.7**	**C**	**25.5**	**C**
	NB	17.2	B	19.9	B	9.8	A	16.5	B	23.3	C	27.8	C
	SB	21.7	C	28.5	C	26.1	C	17.0	B	33.4	C	54.3	D
	EB	8.7	A	3.5	A	9.5	A	2.7	A	42.6	D	6.6	A
	WB	8.8	A	7.7	A	8.5	A	5.9	A	19.8	B	4.7	A

Table 22: Intersection Delay Studies – 17th Street

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
South Street	**Overall**	**19.1**	**B**	**22.1**	**C**	**14.3**	**B**	**11.7**	**B**	**22.2**	**C**	**11.4**	**B**
	NB	25.0	C	23.9	C	25.1	C	20.2	C	59.8	E	16.5	B
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	18.5	B	12.4	B	9.6	A	6.2	A	10.7	B	8.6	A
	WB	13.4	B	27.4	C	15.0	B	15.3	B	13.7	B	14.0	B
"A" Street	**Overall**	**5.9**	**A**	**6.9**	**A**	**6.1**	**A**	**9.6**	**A**	**9.4**	**A**	**10.9**	**B**
	NB	3.8	A	3.3	A	4.3	A	3.0	A	7.0	A	3.5	A
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	4.0	A	10.7	B	5.3	A	11.4	B	9.0	A	15.3	B
	WB	17.2	B	16.1	B	13.8	B	24.8	C	15.2	B	19.4	B
"K" Street	**Overall**	**13.7**	**B**	**13.9**	**B**	**6.6**	**A**	**5.5**	**A**	**8.1**	**A**	**9.8**	**A**
	NB	3.4	A	24.8	C	5.7	A	7.8	A	17.8	B	23.7	C
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	24.8	C	3.1	A	7.3	A	3.8	A	4.3	A	3.8	A
	WB	-	-	-	-	-	-	-	-	-	-	-	-
"L" Street	**Overall**	**11.1**	**B**	**14.6**	**B**	**9.5**	**A**	**6.5**	**A**	**18.1**	**B**	**10.3**	**B**
	NB	7.2	A	12.2	B	4.4	A	7.2	A	8.1	A	9.4	A
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	-	-	-	-	-	-	-	-	-	-	-	-
	WB	14.4	B	16.8	B	15.2	B	5.6	A	28.0	C	11.3	B
Vine Street	**Overall**	**9.1**	**A**	**7.7**	**A**	**9.9**	**A**	**10.1**	**B**	**17.3**	**B**	**11.3**	**B**
	NB	2.7	A	3.5	A	6.5	A	7.9	A	11.7	B	6.9	A
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	10.9	B	15.9	B	9.0	A	8.8	A	20.5	C	17.0	B
	WB	24.7	C	18.1	B	20.3	C	18.5	B	35.0	C	20.7	C

"O" Street

Intersection delay studies were conducted at six (6) signalized intersections along this corridor. Results of both the "before" and "after" intersection delay studies are summarized in Table 23. Delay and LOS are reported for the overall intersection as well as for each individual approach for each of the three peak time periods.

In general, overall intersection LOS and delay were maintained or improved at most of the intersections during the peak time periods. In particular, the intersection of 27th Street/"O" Street showed improvement in overall intersection delay during all three time periods. 9th Street/"O" Street also improved from LOS 'D' to LOS 'C' during the AM Peak and from LOS 'C' to LOS 'B' during the PM Peak. 10th Street/"O" Street improved from LOS 'D' to LOS 'C' during the PM Peak.

Table 23: Intersection Delay Studies – "O" Street

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
9th Street	**Overall**	**37.4**	**D**	**24.8**	**C**	**9.5**	**A**	**8.7**	**A**	**25.9**	**C**	**16.8**	**B**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	7.7	A	4.2	A	4.9	A	4.2	A	6.6	A	3.5	A
	EB	103.2	F	70.3	E	14.0	B	15.9	B	62.4	E	39.7	D
	WB	26.7	C	18.2	B	11.7	B	10.4	B	18.1	B	15.5	B
10th Street	**Overall**	**8.2**	**A**	**6.9**	**A**	**10.7**	**B**	**5.7**	**A**	**42.3**	**D**	**21.2**	**C**
	NB	2.6	A	4.0	A	8.6	A	4.3	A	41.2	D	17.3	B
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	19.8	B	14.0	B	10.8	B	8.7	A	26.4	C	19.6	B
	WB	11.6	B	5.6	A	15.9	B	6.4	A	56.7	E	36.3	D
16th Street	**Overall**	**6.8**	**A**	**6.4**	**A**	**10.9**	**B**	**12.6**	**B**	**17.7**	**B**	**22.2**	**C**
	NB	-	-	-	-	-	-	-	-	-	-	-	-
	SB	3.8	A	7.5	A	5.1	A	11.7	B	22.1	C	31.6	C
	EB	4.2	A	4.4	A	19.2	B	21.5	C	16.5	B	22.6	C
	WB	12.9	B	6.2	A	12.9	B	6.5	A	11.8	B	6.4	A
17th Street	**Overall**	**9.1**	**A**	**9.9**	**A**	**11.8**	**B**	**6.5**	**A**	**19.5**	**B**	**15.0**	**B**
	NB	5.6	A	3.4	A	3.8	A	3.3	A	5.5	A	8.3	A
	SB	-	-	-	-	-	-	-	-	-	-	-	-
	EB	16.3	B	10.5	B	20.0	B	5.6	A	22.4	C	12.1	B
	WB	12.9	B	23.1	C	15.7	B	12.4	B	44.3	D	30.6	C

Table 23: Intersection Delay Studies – "O" Street (cont'd)

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
27th Street	**Overall**	**30.2**	**C**	**23.9**	**C**	**44.3**	**D**	**28.1**	**C**	**54.6**	**D**	**39.5**	**D**
	NB	42.0	D	24.1	C	39.1	D	38.6	D	61.9	E	31.3	C
	SB	43.4	D	29.3	C	44.9	D	23.4	C	72.8	E	22.5	C
	EB	26.7	C	29.9	C	52.4	D	32.8	C	27.8	C	55.3	E
	WB	12.7	B	15.5	B	38.1	D	21.5	C	60.5	E	43.9	D
33rd Street	**Overall**	**17.9**	**B**	**18.2**	**B**	**19.1**	**B**	**18.3**	**B**	**36.1**	**D**	**45.5**	**D**
	NB	35.8	D	45.0	D	51.9	D	34.6	C	40.0	D	49.0	D
	SB	24.3	C	20.2	C	46.9	D	37.8	D	69.0	E	161.5	F
	EB	13.1	B	10.3	B	7.2	A	9.8	A	17.9	B	24.1	C
	WB	11.4	B	12.2	B	7.0	A	14.3	B	40.0	D	15.5	B

Normal Boulevard/Capitol Parkway/"K" & "L" Streets

Intersection delay studies were conducted at six (6) signalized intersections along this corridor. In addition, delay studies were also conducted at the intersection of 40th Street/South Street. Table 24 summarizes the results of both the "before" and "after" intersection delay studies.

Most of the study intersections along this corridor experienced an increase in overall intersection delay during at least one or more time periods. However, not all increases in intersection delay resulted in a decrease in LOS. During the AM Peak, "after" studies indicate that 27th Street/Capitol Parkway improved in LOS from 'E' (58.0 sec/veh) to 'D' (42.8 sec/veh), while LOS decreased from 'B' to 'C' at 48th Street/Normal Boulevard and from 'C' to 'D' at 56th Street/Normal Boulevard. The decrease in LOS at the latter intersections are partly due to an increase in traffic volumes being serviced by the intersections during the "after" studies, resulting in a higher number of stopped vehicles recorded during the study time period.

During the Midday, the intersections of South Street/Normal Boulevard and 40th Street/Normal Boulevard both show a decrease in LOS from 'B' to 'C'. This is primarily due to an increase in traffic volumes being serviced by the intersection during the "after" studies, resulting in a higher number of stopped vehicles recorded. The decrease in LOS is also a result of signal timing adjustments that were made to maintain vehicle progression along Normal Boulevard, creating higher delays on both South Street and 40th Street.

At 27th Street/Capitol Parkway, LOS decreased from 'C' to 'D' during the PM Peak. The increase in delay and decrease in LOS is due to signal timing adjustments that were made to maintain efficient traffic flow along both 27th Street and Capitol Parkway/Normal Boulevard. In particular, eastbound traffic during this time period must transition from the downtown area, that operates at a 75 second cycle length, to Capitol Parkway/Normal Boulevard, operating at a 120 second cycle length. The difference in the two cycle lengths does not allow signal coordination to occur, and therefore, vehicles must 're-platoon' in such a manner as to get "back in step" with the signal timing plan. This 're-platooning' of vehicles can result in increased approach delays at certain intersections.

During the PM Peak, South Street/Normal Boulevard also experiences a decrease in LOS from 'C' to 'D'. Once again, this corresponding increase in overall intersection delay is a result of signal timing adjustments that altered the arrival time for eastbound vehicles, thus increasing the amount of time eastbound vehicles are delayed while waiting for a green light. A possible solution to improve the eastbound approach LOS will be discussed later in the report. Increases in overall intersection delay at the intersections of 48th Street/Normal Boulevard and 56th Street/Normal Boulevard were also indicated by the "after" studies. However, the causes of these delay increases are difficult to identify since signal timings for these two intersections were not altered in order to maintain signal coordination north-south along 48th Street and 56th Street.

Table 24: Intersection Delay Studies – Normal Boulevard/Capitol Parkway/"K" & "L" Streets

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
27th Street	**Overall**	**58.0**	**E**	**42.8**	**D**	**20.7**	**C**	**29.1**	**C**	**30.2**	**C**	**38.7**	**D**
	NB	29.3	C	38.9	D	27.7	C	47.7	D	79.7	E	60.7	E
	SB	81.5	F	75.5	E	45.4	D	25.2	C	52.0	D	53.3	D
	EB	34.1	D	23.9	C	22.0	C	26.9	C	4.8	A	26.0	C
	WB	77.9	E	37.2	D	7.7	A	19.5	B	6.2	A	25.5	C
"A" Street	**Overall**	**27.4**	**C**	**24.2**	**C**	**13.5**	**B**	**12.2**	**B**	**34.3**	**C**	**24.3**	**C**
	NB	29.9	C	17.9	B	8.7	A	5.3	A	26.4	C	25.1	C
	SB	20.8	C	36.0	D	23.9	C	4.9	A	18.7	B	6.9	A
	EB	17.0	B	22.0	C	24.8	C	12.6	B	59.9	E	24.6	C
	WB	38.1	D	32.6	C	23.0	C	35.2	D	68.0	E	61.9	E
South Street	**Overall**	**29.4**	**C**	**28.1**	**C**	**12.2**	**B**	**24.1**	**C**	**29.9**	**C**	**45.9**	**D**
	NB	4.8	A	9.0	A	6.0	A	4.6	A	29.4	C	22.4	C
	SB	18.6	B	17.8	B	37.6	D	3.4	A	38.4	D	21.2	C
	EB	55.4	E	47.5	D	22.0	C	51.2	D	28.6	C	117.4	F
	WB	62.3	E	52.4	D	13.5	B	43.6	D	17.0	B	28.3	C
40th Street	**Overall**	**25.4**	**C**	**26.0**	**C**	**14.0**	**B**	**22.9**	**C**	**29.6**	**C**	**31.5**	**C**
	NB	31.6	C	35.6	D	21.3	C	30.2	C	35.6	D	48.9	D
	SB	31.6	C	58.9	E	52.4	D	49.5	D	31.3	C	45.3	D
	EB	26.1	C	8.3	A	7.9	A	11.1	B	36.5	D	23.9	C
	WB	19.2	B	19.0	B	10.4	B	15.3	B	10.3	B	19.4	B

Table 24: Intersection Delay Studies – Normal Boulevard/Capitol Parkway/"K" & "L" Streets (cont'd)

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
48th Street	**Overall**	**19.5**	**B**	**25.6**	**C**	**19.1**	**B**	**18.5**	**B**	**44.1**	**D**	**82.9**	**F**
	NB	23.5	C	23.4	C	15.9	B	17.3	B	32.9	C	87.2	F
	SB	24.6	C	15.7	B	58.1	E	21.3	C	115.3	F	96.1	F
	EB	12.6	B	28.7	C	27.3	C	21.8	C	15.3	B	85.7	F
	WB	17.4	B	29.9	C	12.7	B	13.3	B	20.5	C	65.0	E
56th Street	**Overall**	**33.2**	**C**	**37.1**	**D**	**13.1**	**B**	**17.8**	**B**	**32.2**	**C**	**43.3**	**D**
	NB	30.2	C	24.3	C	4.9	A	12.7	B	23.5	C	17.6	B
	SB	19.2	B	36.3	D	45.4	D	7.2	A	31.5	C	40.8	D
	EB	23.9	C	35.5	D	25.6	C	29.9	C	35.4	D	61.1	E
	WB	52.9	D	55.8	E	21.6	C	25.6	C	38.6	D	43.4	D
40th Street/ South Street	**Overall**	**17.4**	**B**	**36.8**[1]	**D**[1]	**9.6**	**A**	**24.7**	**C**	**47.7**	**D**	**63.6**	**E**
	NB	14.3	B	17.7	B	23.5	C	10.0	A	31.7	C	14.4	B
	SB	33.4	C	106.7	F	20.2	C	17.8	B	97.5	F	188.6	F
	EB	18.5	B	13.1	B	3.4	A	38.7	D	21.7	C	44.9	D
	WB	8.6	A	28.7	C	4.3	A	25.6	C	33.3	C	28.0	C

[1] AM Peak "after" intersection delay studies at 40th Street/South Street were conducted when 48th Street was closed between Calvert Street and Van Dorn Street, which may have contributed to increased north-south delay.

48th Street/Normal Boulevard showed a significant increase in overall delay, decreasing LOS from 'D' to 'F' during the PM Peak. This increase was unexpected, and therefore, questionable as being representative of daily operations at this intersection, based on the design of the signal timing plan. A potential cause for increased delay on the eastbound approach at 48th Street/Normal Boulevard is the increased green time given to the intersection of South Street/Normal Boulevard. The additional green time allows significantly more vehicles to flow through the intersections of South Street/Normal Boulevard and 40th Street/Normal Boulevard. Since the intersection of 48th Street/Normal Boulevard does not provide as much green time to the eastbound approach as the adjacent intersections to the west, the eastbound approach may not be able to accommodate the traffic demand during brief, concentrated intervals within the PM Peak time period.

The 'triangle', created by the intersections of Normal Boulevard, South Street and 40th Street create an intricate and complex relationship for traffic signal coordination and vehicle progression. Due to the physical proximity of the three intersections and relative amount of traffic volumes that each corridor services during the three peak time periods, coordination of these three traffic signals to maintain optimum vehicle progression along each street is very difficult. Therefore, each of the three streets was prioritized in terms of capacity and relative importance to overall traffic flow.

Based on the amount of traffic on Normal Boulevard during the three peak time periods, maintaining vehicle progression along Normal Boulevard was determined to be the highest priority. Once vehicle progression along Normal Boulevard was accomplished, priority was then given to 40th Street and then to South Street. The decision to give second priority to 40th Street was based on the distance between the intersection of 40th Street/South Street and the other two intersections along Normal Boulevard as well as the number of through lanes on each corridor. Since 40th Street/South Street is closer to 40th Street/Normal Boulevard and 40th Street only provides one through lane in each direction, it was determined that vehicle progression along 40th Street was of higher importance in maintaining traffic flow through the 'triangle' and avoiding spillback into 40th Street/South Street and blocking conflicting traffic movements. Therefore, vehicle progression along South Street was given the lowest priority due to the number of through lanes and distance between 40th Street and Normal Boulevard, which provides for more vehicle storage during the eastbound-westbound red phase of the cycle at both 40th Street and Normal Boulevard.

The intersection of 40th Street/South Street showed a considerable increase in delay during all three time periods. However, as stated above, the increase in delay, and resulting decrease in LOS, is dictated by the relationship of this intersection with both the intersections of 40th Street/Normal Boulevard and South Street/Normal Boulevard. Thus, the coordination between these three intersections was designed to avoid excessive queuing and backup of vehicles into the intersection of 40th Street/South Street, which may result in certain approaches being delayed more than would be expected if this were an isolated intersection that serviced the same amount of traffic.

In general, some increases in average delay were experienced on some approaches at the three intersections of the 'triangle' during the peak time periods. However, significant improvements in delay were noticed on the approaches of Normal Boulevard. Furthermore, frequent queuing and blocking of the intersection of 40th Street/South Street has been minimized and, as the delay studies indicate, excessive queuing of the southbound approach along Normal Boulevard has also been reduced.

Superior Street

Intersection delay studies were conducted at four (4) signalized intersections along this corridor. Table 25 summarizes the results of both the "before" and "after" intersection delay studies. Delay and LOS are reported for the overall intersection as well as for each individual approach for each of the three peak time periods.

In general, signal timing adjustments along Superior Street improved or maintained the LOS at most of the intersections during the peak time periods. Only the intersection of 14th Street/Superior Street showed a decrease in LOS, which occurred during the AM Peak and Midday time periods. Before signal timing adjustments were implemented, this intersection was not coordinated with adjacent intersections and was allowed to respond to fluctuating traffic demands on all approaches. Therefore, by coordinating this intersection with other signals along Superior Street, this intersection must also maintain traffic progression along Superior Street while servicing traffic demand on 14th Street within a set cycle length. Thus, vehicle delay for north-south 14th Street, as well for the overall intersection, increased as a result of the new timing plan. During the Midday, 27th Street/Superior Street improved from LOS 'D' to LOS 'C', and Cornhusker Highway/Superior Street improved from 'D' to 'C' as well during the AM Peak.

Cornhusker Highway

Intersection delay studies were conducted at four (4) signalized intersections along this corridor, and the results of both the "before" and "after" studies are summarized in Table 26. Delay and LOS are reported for the overall intersection as well as for each individual approach for each of the three peak time periods.

In general, "after" studies showed that all the intersections maintained or improved overall LOS, with the exception of 48th Street/Cornhusker Highway during the PM Peak. This intersection showed an increase in overall intersection delay from 48.6 sec/veh (LOS 'D') to 58.8 sec/veh (LOS 'E'), primarily due to increased delay experienced by the southbound approach as a result of reducing the southbound split and overall cycle length. The intersection of 27th Street/Cornhusker Highway improved from LOS 'D' to LOS 'C' during the AM Peak, and 33rd Street/Cornhusker Highway also improved during the Midday from LOS 'C' to LOS 'B'.

Table 25: Intersection Delay Studies – Superior Street

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
14th Street	**Overall**	**19.5**	**B**	**20.4**	**C**	**9.0**	**A**	**12.9**	**B**	**29.5**	**C**	**26.8**	**C**
	NB	19.6	B	62.0	E	11.8	B	29.8	C	84.0	F	56.4	E
	SB	45.4	D	43.7	D	16.3	B	40.8	D	64.0	E	41.7	D
	EB	15.7	B	15.0	B	6.8	A	7.5	A	20.5	C	16.0	B
	WB	11.3	B	12.2	B	8.7	A	4.6	A	11.7	B	16.9	B
27th Street	**Overall**	**32.9**	**C**	**25.4**	**C**	**35.4**	**D**	**29.9**	**C**	**42.4**	**D**	**44.5**	**D**
	NB	17.7	B	19.1	B	37.7	D	37.3	D	52.4	D	42.8	D
	SB	38.1	D	34.2	C	28.2	C	27.7	C	35.9	D	29.1	C
	EB	35.6	D	21.7	C	45.6	D	26.4	C	47.8	D	64.1	E
	WB	30.4	C	22.5	C	31.1	C	25.9	C	34.3	C	41.7	D
48th Street	**Overall**	**4.4**	**A**	**7.2**	**A**	**9.9**	**A**	**8.6**	**A**	**12.0**	**B**	**13.1**	**B**
	NB	11.1	B	12.7	B	22.2	C	17.8	B	21.2	C	37.1	D
	SB	14.8	B	27.7	C	15.3	B	26.3	C	14.4	B	23.3	C
	EB	2.5	A	5.5	A	6.2	A	5.5	A	10.8	B	4.6	A
	WB	1.2	A	3.9	A	4.7	A	4.8	A	6.6	A	7.8	A
Cornhusker Highway	**Overall**	**39.1**	**D**	**32.2**	**C**	**27.0**	**C**	**27.8**	**C**	**32.6**	**C**	**31.6**	**C**
	NB	40.2	D	42.5	D	33.3	C	35.2	D	53.8	D	43.7	D
	SB	82.0	F	29.9	C	45.0	D	29.9	C	51.4	D	25.6	C
	EB	20.9	C	20.4	C	16.8	B	13.7	B	9.9	A	13.1	A
	WB	19.8	B	37.1	D	21.3	C	32.2	C	23.3	C	36.9	D

Table 26: Intersection Delay Studies – Cornhusker Highway

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
11th Street	**Overall**	**37.2**	**D**	**38.1**	**D**	**34.6**	**C**	**31.5**	**C**	**39.3**	**D**	**34.3**	**C**
	NB	28.1	C	19.2	B	28.6	C	21.7	C	30.6	C	23.9	C
	SB	46.7	D	34.2	C	41.1	D	36.9	D	50.7	D	29.5	C
	EB	37.6	D	35.6	D	31.1	C	39.9	D	31.1	C	49.1	D
	WB	38.0	D	54.9	D	38.0	D	32.4	C	48.2	D	40.0	D
27th Street	**Overall**	**43.6**	**D**	**31.6**	**C**	**34.8**	**C**	**30.8**	**C**	**43.2**	**D**	**47.2**	**D**
	NB	50.6	D	39.9	D	38.6	D	30.4	C	54.7	D	85.2	F
	SB	51.6	D	27.2	C	36.8	D	30.9	C	53.6	D	22.5	C
	EB	46.2	D	27.4	C	30.4	C	36.7	D	38.9	D	39.9	D
	WB	28.7	C	33.0	C	33.7	C	25.6	C	26.8	C	33.8	C
33rd Street	**Overall**	**12.5**	**B**	**16.0**	**B**	**24.7**	**C**	**18.1**	**B**	**49.4**	**D**	**46.0**	**D**
	NB	40.3	D	51.4	D	36.0	D	53.2	D	290.3	F	249.7	F
	SB	40.3	D	33.2	C	23.1	C	28.0	C	55.8	E	40.4	D
	EB	5.5	A	7.7	A	13.7	B	8.2	A	12.4	B	13.3	B
	WB	8.3	A	11.1	B	32.6	C	15.7	B	23.0	C	15.5	B
48th Street	**Overall**	**36.0**	**D**	**43.8**	**D**	**30.4**	**C**	**29.0**	**C**	**48.6**	**D**	**58.8**	**E**
	NB	20.8	C	40.6	D	22.1	C	20.4	C	29.9	C	24.7	C
	SB	75.5	E	94.6	F	38.1	D	61.4	E	113.6	F	213.5	F
	EB	39.9	D	22.5	C	21.7	C	15.0	B	52.9	D	30.9	C
	WB	26.8	C	30.0	C	44.3	D	30.3	C	27.6	C	27.2	C

North & South 27th Street

Intersection delay studies were conducted at six (6) signalized intersections along these two corridors. Table 27 summarizes the results of both the "before" and "after" intersection delay studies. Delay and LOS are reported for the overall intersection as well as for each individual approach for each of the three peak time periods.

Many of the intersections showed an increase in overall intersection delay during at least one of the three time periods. However, many of the increases in intersection delay were not accompanied by a reduction in the overall LOS of the intersection. 27th Street/Holdrege Street improved from LOS 'D' to LOS 'C' during the AM Peak, while 27th Street/Van Dorn Street improved from LOS 'C' to LOS 'B' during the PM Peak.

"After" studies indicated that 27th Street/Vine Street decreased from LOC 'C' to LOS 'D' during the Midday and from LOS 'D' to LOS 'E' during the PM Peak. This is partly due to signal timing adjustments that interrupted the coordination of signals along Vine Street both east and west of 27th Street, thus changing the arrival of eastbound and westbound vehicles and increasing approach delay.

LOS decreased from 'B' to 'C' during the Midday at the intersection of 27th Street/South Street. As the "after" study indicates, the delay of both the northbound and southbound approaches contributed the most to the decrease in overall LOS. As mentioned earlier regarding the decrease in northbound average travel speed along South 27th Street, unexpected stops and delays were encountered by the test vehicle at this intersection. As a result, signal timing adjustments were made at adjacent intersections to improve vehicle progression along South 27th Street and reduce delay at 27th Street/South Street. However, since these timing adjustments were made when area schools and universities were not in session and South Street was closed for construction, affecting "normal" traffic patterns, additional delay studies were not conducted at this intersection to measure the improvement in vehicle delay.

Overall, as the "after" intersection delay studies indicate, City staff has done a good job of minimizing overall intersection delay at individual intersections. However, the City should continue to monitor and adjust signal timings along the major arterial streets approximately every three years to adapt to changes in traffic volumes and patterns and maintain efficient traffic flow.

Table 27: Intersection Delay Studies – North & South 27th Street

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
Holdrege Street[1]	**Overall**	**38.9**	**D**	**27.3**	**C**	**22.9**	**C**	**30.8**	**C**	**37.1**	**D**	**40.6**	**D**
	NB	40.4	D	13.3	B	14.7	B	22.2	C	21.5	C	32.2	C
	SB	35.1	D	33.3	C	13.4	B	25.4	C	31.3	C	24.4	C
	EB	42.8	D	37.4	D	36.3	D	40.8	D	46.3	D	61.5	E
	WB	40.2	D	48.9	D	36.9	D	50.8	D	58.8	E	33.9	C
Vine Street[1]	**Overall**	**22.2**	**C**	**23.8**	**C**	**24.1**	**C**	**35.5**	**D**	**37.7**	**D**	**60.6**	**E**
	NB	16.6	B	10.0	A	27.6	C	24.2	C	51.4	D	31.6	C
	SB	16.3	B	19.6	B	15.0	B	28.2	C	29.3	C	27.0	C
	EB	32.2	C	36.3	D	34.3	C	42.9	D	38.9	D	110.4	F
	WB	35.4	D	34.1	C	27.4	C	55.0	D	26.3	C	50.6	D
"A" Street	**Overall**	**26.4**	**C**	**26.7**	**C**	**7.5**	**A**	**11.9**	**B**	**20.8**	**C**	**22.4**	**C**
	NB	27.7	C	8.8	A	8.1	A	5.5	A	21.3	C	13.1	B
	SB	29.9	C	20.4	C	12.0	B	1.7	A	14.3	B	9.4	A
	EB	43.7	D	40.2	D	12.6	B	37.3	D	39.0	D	63.8	F
	WB	30.3	C	65.3	E	17.9	B	28.1	C	11.1	B	11.1	B
South Street	**Overall**	**32.8**	**C**	**28.5**	**C**	**12.4**	**B**	**20.2**	**C**	**47.6**	**D**	**38.6**	**D**
	NB	26.3	C	15.1	B	6.0	A	18.2	B	24.8	C	27.8	C
	SB	32.5	C	16.6	B	3.6	A	13.3	B	21.2	C	12.0	B
	EB	41.3	D	49.8	D	20.9	C	22.9	C	91.3	F	65.9	E
	WB	32.5	C	38.4	D	24.2	C	28.7	C	44.9	D	55.8	E

[1] "After" intersection delay study results, collected in Fall 2000 as part of the previous contract, were used as the "before" study results for this contract.

Table 27: Intersection Delay Studies – North & South 27th Street (cont'd)

Intersection	Approach	Control Delay											
		AM Peak				Midday				PM Peak			
		"Before"		"After"		"Before"		"After"		"Before"		"After"	
		Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS	Control Delay (sec/veh)	2000 HCM LOS
Sheridan Boulevard	**Overall**	**11.4**	**B**	**15.1**	**B**	**7.2**	**A**	**9.9**	**A**	**16.4**	**B**	**15.7**	**B**
	NB	0.4	A	1.6	A	2.7	A	4.9	A	0.7	A	3.8	A
	SB	11.1	B	7.3	A	13.9	B	3.1	A	6.9	A	4.7	A
	EB	34.5	C	53.8	D	22.9	C	47.8	D	71.2	E	61.8	E
	WB	29.8	C	38.9	D	18.2	B	31.9	C	44.7	D	39.0	D
Van Dorn Street	**Overall**	**20.2**	**C**	**23.1**	**C**	**11.8**	**B**	**15.3**	**B**	**24.4**	**C**	**19.6**	**B**
	NB	9.6	A	11.7	B	4.3	A	5.7	A	7.5	A	9.9	A
	SB	7.2	A	5.1	A	23.1	C	9.5	A	16.8	B	4.9	A
	EB	65.3	E	60.5	E	26.3	C	45.9	D	48.2	D	55.8	E
	WB	38.0	D	42.3	D	44.3	D	43.3	D	43.8	D	36.4	D

Analysis of Intersection Improvements

Based on the results of the intersection delay studies conducted for each corridor, intersections were identified where individual approaches of the intersection operate at LOS 'D' or worse. These intersections were further analyzed to determine if traffic operations for the individual approaches and/or the overall intersection would benefit from minor improvements in lane configuration (i.e., adding right-turn or left-turn lanes) and/or signal phasing (i.e., adding or removing permitted/protected phasing). Consideration was also given as to whether any minor improvements would be physically and economically practical and/or feasible. Analyses of potential improvements were performed using Synchro, a nationally accepted computer software package incorporating the methodologies of the 2000 HCM.

Lead/Lag Protected-Permissive Left-turn Phasing (Dallas Lefts)

One of the improvements that is being recommended as part of this project to improve traffic flow and signal progression along arterial streets is the use of lead/lag protected-permissive left-turn signal phasing. The concept of this type of left-turn phasing is to alter when the protected phase of a left-turn movement occurs during each cycle in order to create longer bandwidths for vehicle progression between adjacent signals and improve bi-directional traffic flow along an arterial street.

In order to implement this type of phasing, the left turn is given its own louvered or optically programmable signal head that makes the display invisible to the adjacent through lanes. The green, yellow and red ball indications on the louvered signal head are wired so that they display the same indication as the opposing/oncoming traffic during the permissive portion of the phase. This type of signal phasing was developed in Dallas, Texas as a solution to eliminate the lagging left-turn trap problem.

The lagging left-turn trap problem occurs when leading and lagging opposing left-turn movements with conventional five-section signal heads. Once the leading left-turn movement receives the green ball indication (permissive left-turn phase), there is the potential that the vehicle will wander into the intersection, anticipating a sufficient gap in traffic. However, should a sufficient gap in oncoming traffic never materialize, the driver will get a yellow ball display. Upon receiving a yellow ball display, the driver of the vehicle would assume that oncoming traffic would stop and allow him/her to clear the intersection. However, oncoming traffic in a lead/lag phasing situation would not necessarily stop, thus promoting driver confusion for the left-turning vehicle/driver and creating an unsafe situation. By providing a louvered left-turn signal head that displays the same indication as the oncoming display, the leading left-turn movement will continue to receive a green ball indication, the same as the oncoming display, even though the vehicles in the adjacent through lanes receive a yellow ball and red ball indication. Thus, this will allow the leading left-turn vehicle to occupy the center of the intersection and safely clear at the proper time in the cycle.

Since this a relatively new concept to the City of Lincoln, representatives from City of Lincoln staff and The Schemmer Associates Inc. took a field visit to the City of West Des Moines where this type of phasing is being used on a daily basis. The operation of the signal phasing was video taped and a copy of the video was submitted to the City of Lincoln.

The following discussion of improvements to individual intersections will indicate locations where this type of signal phasing is recommended for implementation.

27th Street/"O" Street

"After" intersection delay studies at this location show that this intersection currently operates at LOS 'D' during the PM Peak, with the eastbound and westbound approaches operating at LOS 'E' and 'D', respectively. The northbound approach also operates at LOS 'D' during the Midday.

Future improvements to this intersection are scheduled to be constructed in Spring 2004. These improvements include the elimination of the eastbound right-turn lane, the addition of dual eastbound and westbound left-turn lanes with lead/lag, protected-only phasing, and the use of lead/lag protected-permissive left-turn phasing for the northbound and southbound approaches. Along with the geometric and phasing improvements, it is further recommended to lead the westbound left-turn movement and lag the eastbound left-turn movement during all three peak time periods to maintain optimal vehicle progression along "O" Street. It is also recommended to lead the southbound protected left-turn phase and lag the northbound protected left-turn phase to achieve the best progression north-south along 27th Street. Therefore, the southbound green, yellow and red ball indications on the left-turn signal head should be louvered to make the displays invisible to the adjacent southbound through lanes. It is anticipated that these improvements will improve the overall delay from 51.2 sec/veh to 37.3 sec/veh during the PM Peak.

Further analysis also indicates that the delay of the intersection could be further reduced with the addition of northbound, eastbound and westbound right-turn lanes. Analysis of the PM Peak showed that the addition of these right-turn lanes would improve the overall delay to 27.5 sec/veh (LOS 'C'), with a corresponding improvement in the volume-to-capacity ratio (V/C) from 1.03 to 0.94. However, existing right-of-way constraints near the northbound, eastbound and westbound approaches make these improvements difficult to implement.

33rd Street/"O" Street

This intersection currently operates at LOS 'D' during the PM Peak time period, with the northbound approach operating at LOS 'D' and the southbound approach at LOS 'F'. The northbound approach also operates at LOS 'D' during the AM Peak, and the southbound approach operates at LOS 'D' during the Midday.

This intersection received signal and geometric improvements in Fall 2003, which included realignment of the northbound and southbound left-turn lanes and the addition of a southbound right-turn lane. Synchro analysis of this intersection also indicates that this intersection would benefit from the addition of a northbound right-turn lane. However, due to right-of-way constraints near the northbound approach, this improvement would be difficult to implement.

Vehicle progression along "O" Street, as well as overall intersection delay at 33rd Street/"O" Street, would also benefit from the implementation of lead/lag protected-permissive eastbound and westbound left-turn movements. However, further analysis should be conducted to include the potential coordination of traffic signals east of 33rd Street in order to determine which direction the protected left-turn phase should lead and which direction should lag.

27th Street/Capitol Parkway

This intersection is characterized by high traffic volumes, especially during the AM Peak and PM Peak time periods when the intersection operates at LOS 'D'. Based on the distribution of turning movement volumes and the constrained right-of-way, very few possibilities for minor improvements exist.

However, analysis of the AM Peak time period indicates that traffic operations for the westbound approach would benefit from the addition of a right-turn lane. According to Synchro, a right-turn lane would improve delay from 129.7 sec/veh (LOS F) to 73.1 sec/veh (LOS E). Several field observations confirm that a westbound right-turn lane would benefit the approach by removing right-turning vehicles from the through lane so that through vehicles can continue to progress through the intersection at a more stable rate of speed.

City staff indicated that this intersection is currently being designed for future traffic signal and geometric improvements. Therefore, it is recommended that the addition of a westbound right-turn lane be investigated to see if it is physically and economically feasible to implement.

South Street/Normal Boulevard

This intersection is in close proximity to both intersections at 40th Street/Normal Boulevard and 40th Street/South Street. During the PM Peak, "after" studies showed that this intersection operates at LOS 'D'. Even though this intersection is characterized by high traffic volumes, especially during the PM Peak time period, the LOS and amount of delay experienced at this intersection is significantly influenced by the relationship with the intersections of 40th Street/South Street and 40th Street/Normal Boulevard. Therefore, no minor improvements are recommended at this time. However, the eastbound approach delay would benefit from improvements recommended at the intersection of 27th Street/South Street, which is discussed later in the report.

40th Street/Normal Boulevard

This intersection currently operates at an acceptable LOS 'C' during all three peak time periods. However, the northbound and southbound approaches operate at LOS 'D' or worse during all three time periods with the exception of the northbound approach during the Midday. Due to the close proximity of this intersection to 40th Street/South Street and South Street/Normal Boulevard, minor geometric improvements would not be a viable option to improve the LOS of these two approaches.

Based on the right-turn volume of the eastbound approach and field observation during the PM Peak, it appears that an eastbound right-turn lane would be beneficial to eastbound traffic flow. Analysis indicates that the addition of an eastbound right-turn lane would improve approach delay from 17.3 sec/veh (LOS 'B') to 8.5 sec/veh (LOS 'A') during the PM Peak. This addition would also benefit the progression of eastbound vehicles by moving right-turning vehicles out of the through lane so that through vehicles can continue to progress through the intersection at a more stable rate of speed.

40th Street/South Street

This intersection has been shown to operate at LOS 'D' during the AM Peak and LOS 'E' during the PM Peak. However, as stated earlier, the LOS of this intersection is dictated by its relationship with the intersections of 40th Street/Normal Boulevard and South Street/Normal Boulevard. Therefore, no minor improvements are necessary at this location. However, further detailed analysis will be needed along 40th Street and the intersections of the 'triangle' if volumes continue to increase and LOS continues to decline, even with additional signal timing adjustments for changes in traffic patterns.

48th Street/Normal Boulevard

"After" studies show that this intersection operates at LOS 'F' during PM Peak. As stated earlier, this low LOS seems questionable as being representative of daily traffic operations at this intersection. However, based on high eastbound right-turn volumes at this intersection and analysis using Synchro for the PM Peak time period, this intersection would benefit from the addition of an eastbound right-turn lane. This addition would improve delay for the eastbound approach from 12.8 sec/veh (LOS 'B') to 8.4 sec/veh (LOS 'A'). This addition would also benefit the progression of eastbound vehicles by moving right-turning vehicles out of the through lane so that through vehicles can continue to progress through the intersection at a more stable rate of speed. However, existing right-of-way constraints near the eastbound approach make this improvement difficult to implement.

56th Street/Normal Boulevard

"After" studies show that this intersection operates at LOS 'D' during the AM and PM Peak. Analysis of this intersection for the PM Peak time period indicates that this intersection would benefit from the addition of an eastbound right-turn lane. This addition would improve delay for the eastbound approach from 28.8 sec/veh (LOS 'C') to 13.9 sec/veh (LOS 'B'). However, existing right-of-way constraints near the eastbound approach make this improvement difficult to implement. Efficient operation of the eastbound approach is also constrained by unbalanced lane utilization and "bottlenecks" created by merging lanes of traffic downstream of the intersection, east of 56th Street.

27th Street/Holdrege Street

This intersection currently operates at LOS 'D' during the PM Peak time period. Although the northbound and southbound approaches operate at LOS 'C' or better during all three time periods, the eastbound and westbound approaches operate at or near LOS 'D' or worse. The decreased LOS and operational efficiency of the eastbound and westbound approaches is primarily due to unbalanced lane utilization and "bottlenecks" created by merging lanes of traffic downstream of both approaches.

Although the northbound and southbound approaches operate fairly efficiently, the use of lead/lag protected-permissive left-turn phasing would assist in improving signal coordination and vehicle progression along North 27th Street. Therefore, it is recommended that the proper wiring and hardware be installed at this location to allow for this type of operation. Once the hardware is available, further analysis should be done to determine the proper lead/lag combination in order to maximize north-south traffic flow.

27th Street/Vine Street

This intersection currently operates at LOS 'D' and LOS 'E' during the Midday and PM Peak, respectively. The deficient LOS on both the eastbound and westbound approaches is primarily due to the lack of coordination between adjacent signals east and west of 27th Street. Further adjustment of traffic signals along Vine Street will help to improve the LOS at this intersection.

Although the northbound and southbound approaches operate fairly efficiently, the use of lead/lag protected-permissive left-turn phasing would assist in improving signal coordination and vehicle progression along North 27th Street. The proper wiring and alignment of signal heads is planned to be implemented in Spring 2004, along with improvements to the intersection of 27th Street/"O" Street. Once the proper wiring and hardware is installed, this new signal phasing can be implemented. It is recommended to lead the southbound protected left-turn phase and lag the northbound protected left-turn phase to achieve the best progression north-south along 27th Street. Therefore, the southbound green, yellow and red ball indications on the left-turn signal head should be louvered to make the displays invisible to the adjacent southbound through lanes.

27th Street/South Street

Based on "after" studies performed, this intersection operates at LOS 'D' during the Midday and LOS 'E' during the PM Peak. Most notably, the eastbound and westbound approaches operate at LOS 'D' or worse. The decreased LOS of the eastbound and westbound approaches is primarily due to the lack of signal coordination east of 27th Street and the difference in cycle lengths west of the intersection.

To improve traffic operations at this intersection and vehicle progression along 27th Street, it is recommended that lead/lag protected-permissive left-turn phasing be incorporated into the signal operation for the northbound and southbound approaches. The necessary wiring and alignment of signal heads is scheduled to be installed by Fall 2003. Once the proper wiring and hardware is installed, this new signal phasing can be implemented. It is recommended to lead the southbound protected left-turn phase and lag the northbound protected left-turn phase to achieve the best progression north-south along 27th Street. Therefore, the southbound green, yellow and red ball indications on the left-turn signal head should be louvered to make the displays invisible to the adjacent southbound through lanes.

Lead/lag protected-permissive left-turn phasing should also be investigated for the eastbound and westbound approaches to improve vehicle progression and signal coordination with intersections east of 27th Street on South Street. Improved eastbound vehicle progression would especially benefit the eastbound approach at South Street/Normal Boulevard. Further analysis will be needed to develop the proper lead/lag combination.

27th Street/Kmart Drive

Although an intersection delay study was not conducted at this location to determine the LOS during the three peak time periods, travel time runs indicate that this intersection experiences some delay northbound and southbound along 27th Street, lowering average speeds on adjacent roadway segments. To improve traffic operations at this intersection and vehicle progression along North 27th Street, it is recommended that the incorporation of lead/lag protected-permissive left-turn phasing be investigated for the northbound and southbound approaches. Further analysis will need to be conducted to develop the proper lead/lag combination.

Several other intersections with approaches operating at LOS 'D' or worse were also identified. However, further analysis and investigation of these locations did not reveal any potential minor improvements that would benefit or improve the operation of the intersection.

MOBILITY BENEFITS OF IMPROVED SIGNAL TIMINGS

Many mobility benefits can be attained through improvements in signal timings. These benefits are in the form of vehicle wear savings, stop savings, fuel savings and vehicle time savings. The estimation of the benefits achieved from improved signal timings are directly related to the relative change in average travel time and delay experienced along the corridor as well as on side-street approaches.

One component of the calculation of mobility benefits, vehicle time savings, relates to the amount of time drivers and passengers spend in their vehicles, and the dollar value that time is worth to them. The other component, vehicle operating cost, includes those items associated with the operation and maintenance of vehicle. These two components are combined into the following formula to calculate the *Value of Time* per vehicle:

$$VoT = [(OF \ \ x \ AWR) + VOC]$$

where:

VoT = Value of Time ($/min/veh)
OF = Occupancy Factor = 1.178 (occupants/veh)
AWR = Average Wage Rate/Occ. = $0.17/min/occ. ($10.22/hr/occ.)
VOC = Vehicle Operating Cost = $0.205/min/veh. ($12.31/hr/veh.)

The average wage rate was calculated based on an average income of $21,265 per person for Lancaster County as determined from 2000 census data. The average vehicle operating cost was provided by City of Lincoln staff.

This formula equates to a monetary value of time for each vehicle of $0.41/min/veh. This number is then multiplied by the difference in the number of vehicle-minutes of delay *before* making signal timing adjustments and *after* making signal timing adjustments.

The change in aggregate vehicle delay was estimated using the results of both the travel time studies and intersection delay studies, along with vehicle volumes along each corridor, including side-street volumes, for each of the three peak time periods. Table 28 summarizes the estimated increase or decrease in aggregate vehicle delay during the three peak time periods and the corresponding cost or benefit for each corridor.

Table 28: Mobility Benefits of Signal Timing Modifications

Study Corridor	Daily Vehicle Time Savings		Annual Vehicle Time Savings	
	(Minutes)	($)	(Hours)	($)
9th Street	2,851	$1,155	12,354	$300,384
10th Street	1,184	$480	5,130	$124,750
16th Street	876	$355	3,796	$92,303
17th Street	1,238	$502	5,366	$130,470
"O" Street	2,750	$1,114	11,916	$289,733
Normal Blvd./ Capital Pkwy./ "K" & "L" Streets	(5,570)	($2,257)	(24,135)	($586,863)
Superior Street	5,120	$2,075	22,186	$539,470
Cornhusker Highway	3,877	$1,571	16,800	$408,506
North 27th Street	(3,844)	($1,558)	(16,656)	($405,011)
South 27th Street	(2,043)	($828)	(8,854)	($215,281)
13th & South	414	$168	1,792	$43,576
TOTAL	**6,853**	**$2,777**	**29,694**	**$722,036**

Note: Negative values are shown in parentheses.

As Table 28 shows, it is estimated that the modification of signal timings along these study corridors during the peak periods of the day result in a net annual savings of approximately $722,000. Since it is desirable to evaluate and update signal timings on a three-year basis, the signal timing modifications made along these corridors produce an estimated three-year savings of approximately $2,166,000.

Furthermore, Table 28 indicates that signal timing modifications resulted in a 'negative benefit' for three of the corridors; Normal Boulevard/Capitol Parkway, North 27th Street and South 27th Street. Both the Normal Boulevard/Capital Parkway and North 27th Street corridors experienced a benefit in mobility savings for vehicles traveling along the study corridors themselves. Therefore, the 'negative benefit' is mostly attributed to the increase in delay on the side-street approaches. For Normal Boulevard/Capitol Parkway, the most significant increases in delay occurred at the three intersections of the triangle and at the 48th Street and 56th Street intersections. For North 27th Street, the most significant increase in delay occurred on the eastbound and westbound approaches of 27th Street/Vine Street.

The 'negative benefit' of the South 27th Street corridor can be mostly attributed to the increased travel time and delay of vehicles traveling along the corridor itself during the Midday time period. However, as discussed earlier in this report, adjusted signal timings for the Midday are expected to improve vehicle progression, and therefore, contribute to more 'positive' benefits to the corridor.

ADDITIONAL DATA COLLECTION ACTIVITIES

In addition to collecting travel time and intersection delay data for the purpose of monitoring arterial streets and optimizing timing plans, as discussed earlier, traffic volume data was collected for use in developing optimized signal timings as well as for general use by City staff. These data collection activities included conducting 6-hour turning movement counts and pedestrian/bicycle counts at 20 signalized intersections along the study corridors to obtain updated peak hour traffic volumes during the AM Peak, Midday and PM Peak time periods. Forty-eight-hour mechanical counts ("tube counts") were conducted at 50 locations to obtain average daily traffic volumes. These locations are illustrated in Figures 6 and 7.

Results of these data collection activities were submitted to City staff in December 2002.

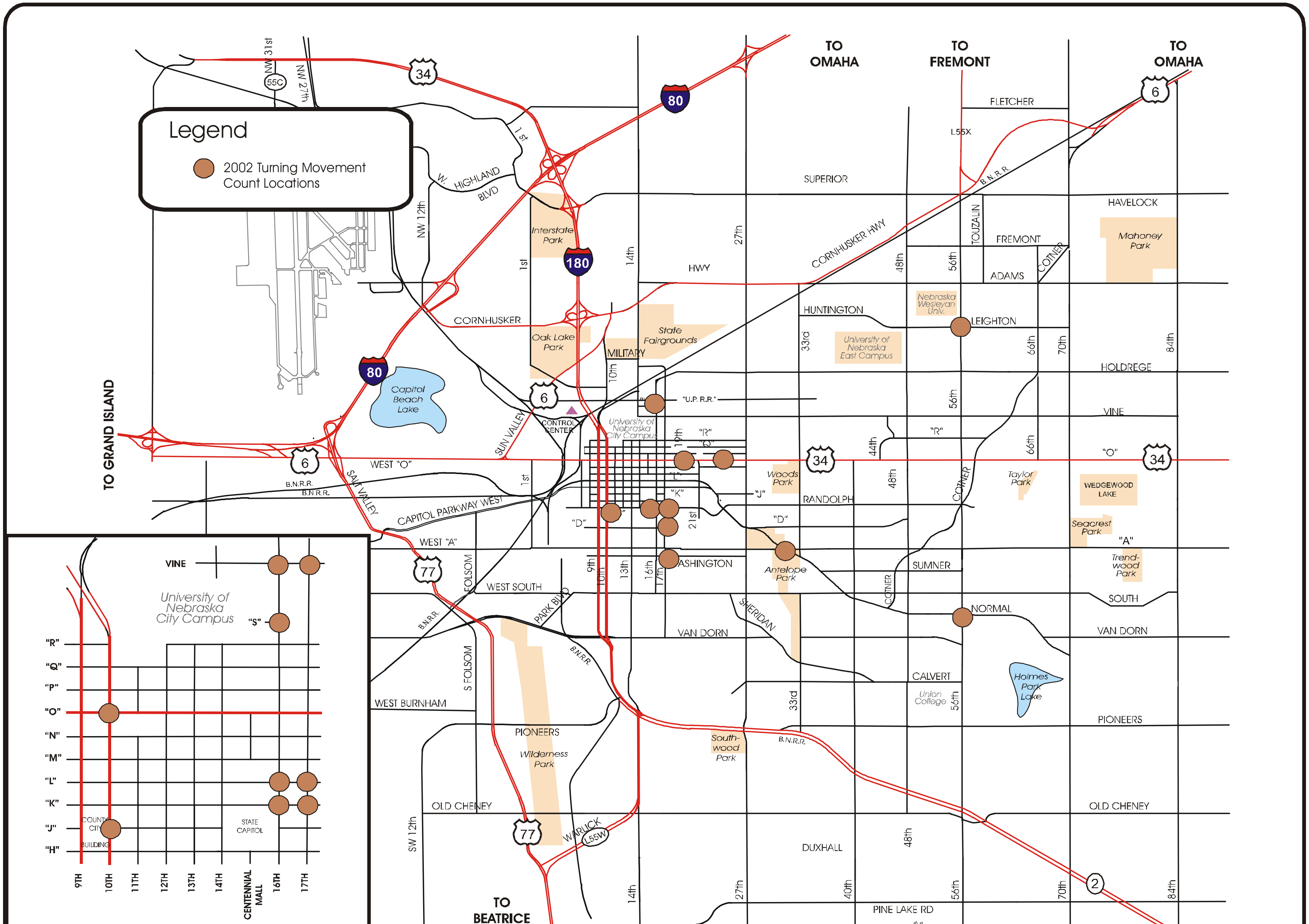

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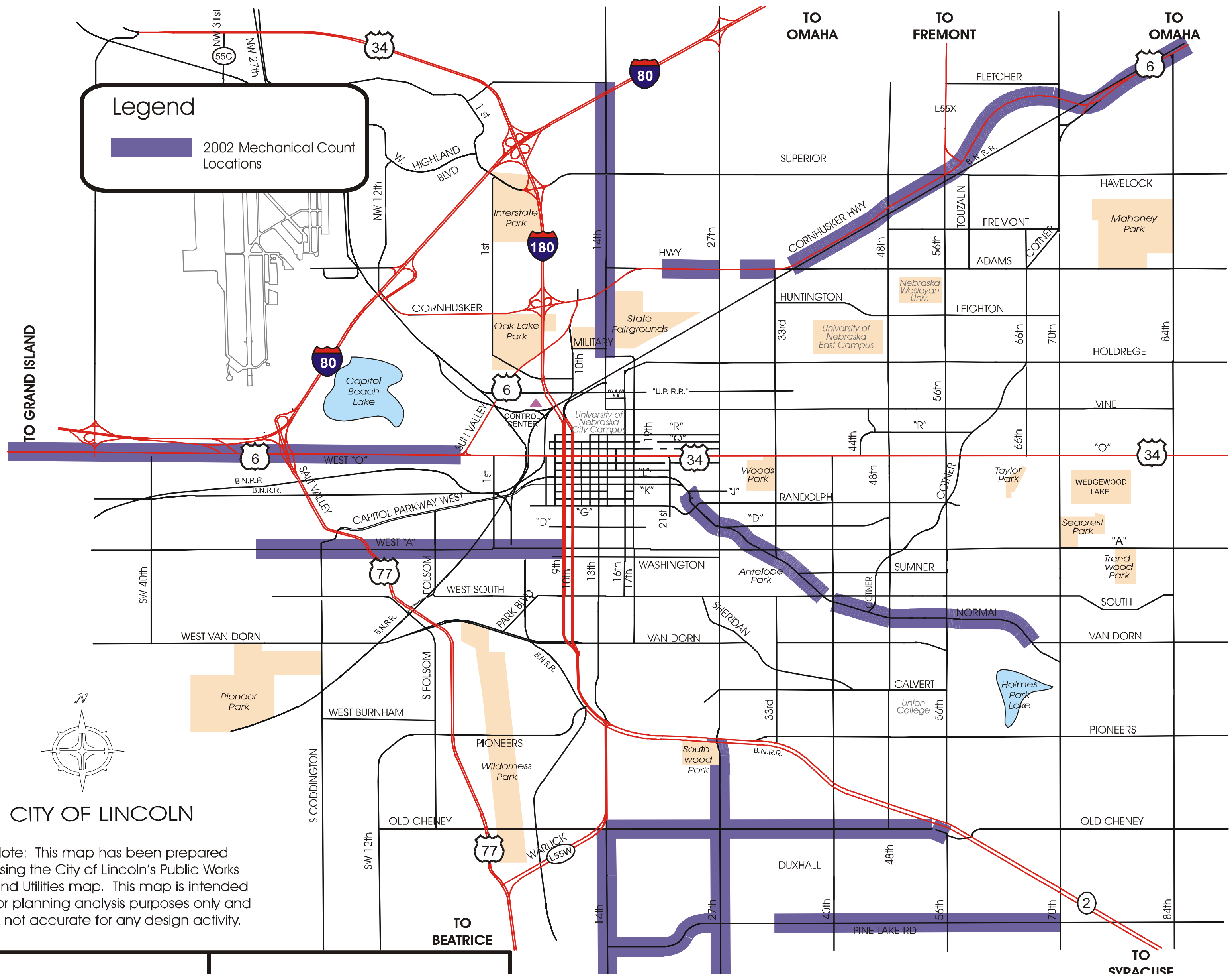
Figure 6: Turning Movement Count Locations

Note: This map has been prepared using the City of Lincoln's Public Works and Utilities map. This map is intended for planning analysis purposes only and is not accurate for any design activity.



Note: This map has been prepared using the City of Lincoln's Public Works and Utilities map. This map is intended for planning analysis purposes only and is not accurate for any design activity.

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Figure 7: Mechanical Count Locations